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With the advent——

of this, the first number of Vol. 6 of FEILDEN'S MAGAZINE, the second year of the new century opens. Looking forward to the potentialities of the advancing era, what thoughts are conjured up in the minds of those who really have the interests of our country at heart! The question again arises uppermost, Are we going to hold our own? I am firmly of belief that this is possible if the manufacturers and workers of Great Britain will but fix their minds on the main object and pursue it for all it is worth.

It is a striking sign of the times to find that our future King finds it necessary, in a public speech of rare eloquence and wisdom, to remind our manufacturers that there was "an impression abroad that the Old Country must wake up if she intends to maintain her old supremacy against foreign competition." No Prince of the Realm ever did a greater service to his country than the present Prince of Wales by his outspoken utterance in this connection, and the careful observations made by him during his recent tour, and which found vent in the warning he uttered at the recent Guildhall reception, should sink deep down into the mind of every trader of this country.

We must above all things make our Colonial brethren feel that we are one in heart and mind with them. Co-operation and reciprocity must be no mere figures of speech; consolidation of interests must be the order of the day. No one knows better than the men of our Colonies, who are endeavouring to work hand-and-glove with us, what a disaster it would mean to them as well as to us if our foreign rivals were to succeed in reducing the trade of the Old Country to that of a second or third-rate Power. Not that we have been entirely idle to the exigencies of the times. Our manufacturers have of late been roused from the seeming lethargy which characterised the actions of many of those who had considered for years past that they were in an unassailable position, and too independent to worry over things. The idea of "hustle" has now got hold of not a few, and we have reason to be thankful in more ways than one for the American invasion of our industries at home and for the lessons that have been taught us.

But there is need for further action on our part, for constant thought, for vigorous initiative, for unremitting care and attention to the requirements and necessities of the world's consumers. Markets have now not to be easily annexed as of old, but to be held where we are already strongly in evidence, and those new markets which are opening to commerce, and which foreign capitalists and traders are seeking to secure to themselves, have to be fought for with all our might and main. If the business men of this nation in general acknowledge and confess the facts in the living present, on the only lines which common-sense dictates, we shall not have the pitiful sight of the blood and treasure of the nation being poured out for the benefit of the trade of our commercial antagonists, and Great Britain will once more give to the world an unmistakable exhibition of her strength and resource—in fact, she will *more* than hold her own.

With this earnest hope and expectation, I sincerely wish my readers, individually and collectively,

A Most Prosperous New Year.

Theo. Feilden.

Standardisation.

PROOFS are by no means wanting to show that British manufacturers as a class are alive to the lessons taught by foreign competition during recent years. Members of the general public, who know nothing of engineering practice but what may be gleaned from sensational, but hardly reliable, articles in a certain section of the daily press, may possibly imagine that foreign competition is quite a new thing. Practical engineers know that this is not the case, and they are able to point to many branches of industry in which substantial improvements have been continuously made for many years past, with the result that our country has successfully held its own against the awakened world. Of late years foreign competition has assumed more formidable dimensions, which have undoubtedly been much exaggerated by writers possessing little knowledge of their own and an unlimited capacity for the absorption of rhetorical literature. Industrial enterprise in Germany, from which much was feared in certain quarters, has suffered a severe check owing in great measure to excessive haste in the pursuit of wealth. American enterprise still continues, and will continue to be a factor for serious consideration, although it is unwise to accept advertising notices in the American press as a true measure of the injury done to our own industries. We have repeatedly called attention to matters in which improvement has been necessary in this country; and, on the other hand, we have had the gratification of pointing to many instances showing that the lessons afforded by competitive conditions have been by no means neglected. The series of articles now running in our pages, on "How Great Britain is Meeting Foreign Competition," furnishes sufficient proof that this country is quite wide awake, and prepared to maintain with credit the traditions of the past. In the latest article of the series the subject of "Specialisation" is particularly discussed, and its consideration is resumed in the present issue.

Whilst specialisation does not at all involve standardisation in the broad sense of the term, it would nevertheless be difficult to introduce a general scheme of systematised production for any particular branch of engineering work, except with the help of specialists and specialised methods of manufacture. For specialisation as applied to an individual establishment may be made an easy stepping-stone to standardisation if specialists will meet together to discuss in a friendly way the means to be taken for the abolition of insignificant and unnecessary differences of design and construction. The employment of Whitworth's standard for screw threads has been found to be an unmixed blessing, although some few firms, chiefly cycle and sewing-machine makers, continued to use odd threads until quite recent times. Standard threads for steam, water, and gas-pipes are equally advantageous; but here again one or two firms still persist in the adoption of special threads, presumably with the object of retaining customers. This is mistaken policy, for whilst a customer may here and there be retained, there are many others who absolutely refuse to buy any pipes that are not threaded to the standard gauge. Turning to another important branch of work, we find that the standardisation of steel plates and bars for shipbuilding is already practically effected, and that the question of the further uniformity of rolled steel is under consideration by the Institution of Civil Engineers. This subject undoubtedly presents difficulties, one of which is the tender affection of the Great George Street engineer for sections specially rolled to his own dimensions, and another arises out of the essential difference between the British and the metrical units of measurement. Possibly this difference will prove to be an insuperable obstacle to universal standardisation, but it need have no adverse effect upon the attainment of uniformity in this country. American engineers have already made progress towards the standardisation of various productions, and at the present time the American Society of Mechanical Engineers is seriously considering the standardisation of engines and dynamos

in the following respects: the standard sizes of units; the corresponding revolutions per minute; the sizes of shafts for centre-crank and side-crank engines; the length along the shaft required for the generator; the height of axis over top of sub-base; the width of top of sub-base; armature fit; overload capacity of engines and generators; brush-holders; holding-down bolts; keys, and outboard bearings. None of these things affect originality or distinctiveness of design. and it is significant that the preliminary recommendations sent out by the Society were almost without exception approved by manufacturers, who showed not only a willingness to adopt the suggestions, but an appreciation of the advantages to be secured thereby. There seems to be a general feeling amongst engineers in the United States that systematisation of the kind must have the effect of reducing the cost of production, of expediting deliveries, and of removing many causes of complication. Our readers can probably call to mind numerous classes of machines in which uniformity in respect of details would be a wonderful advantage to manufacturers and the public. We do not for a moment suppose that rival makers of specialties in comparatively limited use will ever combine to make their productions more alike, for diversity seems to be an unalterable item of their creed. But there are many classes of machines and mechanical appliances in which uniformity on points of detail would not be considered objectionable by the producers, and so far as these are concerned we think some action might very well be taken by the Institution of Mechanical Engineers. One industry in particular, that of locomotive building, is in especial need of a helping hand. Every builder has his own types of design, which is natural and proper, but the minute details of construction also differ in trivial and unimportant respects from corresponding details in the engines of other builders, which is natural but undesirable. Unfortunately there is the further difficulty that no engine-builder can undertake the regular production of his locomotives in advance of actual orders, because he cannot be sure of selling them within reasonable limits of time. Almost every railway engineer in this country has pet fancies of his own, which are forced upon the British locomotive builder; every consulting engineer has also his idiosyncrasies, and nearly all foreign and colonial railway companies have some special stipulations to make when placing orders. Such disturbing elements are very undesirable, but before they can be abolished, locomotive builders must come together for the purpose of formulating and carrying into effect the standardisation of engines in such a manner that all reasonable requirements, however varied, may be covered by one or other type or size of engine included in a standard schedule. The preparation of such a schedule and its accompanying specifications, for use as required, ought to remove many of the disadvantages under which locomotive makers now suffer, and perhaps even rail way engineers and consulting engineers might cease in a measure from the invention of meaningless variations if engine-builders were able to show substantial agreement amongst themselves. Much more might be said on this topic, but space now forbids. We trust, however, that every one of our readers will continue its consideration, and endeavour to do something in aid of a movement so much calculated to benefit the engineering industries of Great Britain.

Inventors and Manufacturers.

In our last issue we pointed out that, owing to our peculiar patent-law legislation, which permits the granting of a patent to anybody applying for it in conformity with the regulations, whether his alleged invention has been anticipated or not, or whether his specifications are full of absurdities or not, the difficulties in the way of an inventor who desires to interest a manufacturer or a capitalist in his invention are far greater than elsewhere, above all, than in the United States. This fact, in conjunction with others, renders it necessary, we added, to

devise a system by means of which, from the mass of inventions ever pouring forth, such as appear to be of real value may be separated and, if necessary, funds may be provided for giving promising inventions a practical test. We tentatively suggested the establishment of an association composed mainly of leading manufacturers and technical experts, the latter ready to undertake, by a process of elimination, the discovery of what appear to be patents of practical value among the heap of rubbish which every month is patented in the United Kingdom, and either to try them in their own laboratories or to supervise their trial on a large scale for which the former would be willing to give an opportunity in their works.

In either case, of course, members of the association would bear in common the cost of such trials, including fees due to such experts as may have been engaged in work for the association, and the amounts to be paid for refunding the outlay for material or wages on the part of such owners of works as may have placed their premises and staff at the disposal of the association, together with what would appear to be a fair equivalent for loss of profit elsewhere while aiding the association. Absolute fairness would have to be the motto of such an association if it is to be successful, fairness not only to its members, but to all that have dealings with it. For this reason it is of the utmost importance that all who are to be admitted to membership should not only have the highest standing in their special class, be it as prominent manufacturers and employers of labour or as scientific and technical experts, but should also be men of undoubted integrity, for it is obvious that otherwise the inventor would not readily permit anybody to become acquainted with every detail of his invention, as he must do if he wishes to have it tested according to its merits, nor would that mutual confidence, which is necessary for the success of such an association as we have in mind, be possible between manufacturers, above all between those in the same branch of industry, unless each recognizes in the other a man of high moral character and strict honesty in all his dealings.

These general principles being granted, however, we are convinced that an association of the kind outlined above would render valuable service to the industries of our country, for it would remove, pending further legislation, one of the greatest obstacles in the way of competing on, at least, fairly equal terms with foreign, notably transatlantic, rivals—viz. the obstacle in the way of availing ourselves speedily of the latest progress made in substituting mechanical for manual labour.

It must not be imagined, however, that it is a simple matter to put the above-named general principles into practice, or to devise a system for securing the greatest benefit from their membership to all who have joined the association. We have had since the publication of our December issue numerous letters from correspondents interested in our suggestion, and, on the whole, the idea which we there expressed appears to have found many sympathisers; but there are some difficulties in the way of its execution which apparently escaped not only our friendly but also our hostile critics.

The effusions of the latter are even more welcome to us at this moment than the kindly appreciation of our friends, for nothing is so stimulating when the solution of a difficult problem has to be found as adverse criticism and declarations that we are attempting the impossible. So far there has been little said that could induce us to change our opinion. The most common objection raised against our plan has been the assertion that the rivalry among manufacturers in the same line of business is so great that most of them would much rather incur a heavy expenditure in order to get hold of an invention, giving them an advantage over their competitors, be they British or not, than secure, by a moderate outlay, a general advance in their special branch of industry, which would equally benefit their rivals provided they happened to be members of the association. We grant that, under ordinary circumstances, selfishness is a sufficiently prominent feature of character to be counted with, but we bear in

mind that at this moment Great Britain practically stands alone against the world in her effort to regain her position as the leader among industrial-nations. On such occasions, Englishmen quickly forget petty rivalry, and do not require to be reminded that the nation's interests have higher claims upon them than their own. Far more important is a difficulty that seems to have escaped alike our friends and our opponents, namely, that though technical experts can give information to the association which inventions, among the heap of abortive productions, give fair promise of success, they are not in a position to give to these meritorious patents the validity that patents possess in the United States for instance, owing to the fact that there no patent is granted for an invention that has been previously patented; while even the most promising British patents have no certain value at present until the courts have given a decision regarding their priority. To settle this question of priority before a legal contest regarding it has taken place will therefore remain an important problem, on which we may have to say something at an early opportunity.

American Reciprocity.

Reciprocity, says an American writer, has got outside the covers of Webster's Dictionary. It has not yet got outside of Congress, but has been introduced there by President Roosevelt with honour and emphasis. Following up the late Mr. M'Kinley, Mr. Roosevelt recommends some relaxation of the fiscal policy of the United States in order to the extension of foreign markets for American products. "The phenomenal growth of our export trade [he says] emphasises the urgency of the need for wider markets and a more liberal policy in dealing with foreign nations." There has been some not unnatural disposition in this country to clap hands and shout for joy at what is regarded as evidence of a broadening of economic principles in America—a turning towards Free Trade. But is it? "Reciprocity must be treated as the handmaiden of Protection." So says the President, and he further declares that nothing could be more unwise than to disturb the business interests of the country by any general tariff changes. Sweeping revisions of the tariff are apt, he says, to produce conditions closely approaching panic, and these must be avoided. Yet "it is eminently desirable to combine with the stability of our economic system the supplementary system of reciprocal benefit and obligation." Desirable, certainly; but is it possible? It is not by any means clear how America is going to adhere to rigid Protectionism and yet win concessions from foreign Protectionists at one and the same time.

There is no doubt about Protection being retained so long as the Republicans are in power—and even longer. The President's Message declares that "our first duty is to see that Protection in every case where it is needed is maintained, and that Reciprocity be sought for as far as can safely be done without injury to home industries. Duties must not be reduced below the point covering the difference between labour cost here and abroad," and "the natural line of development for the policy of Reciprocity will be in connection with those of our productions which no longer require all the support once needed to establish them on a sound basis, and with those others where either because of natural or economic causes we are beyond the reach of successful competition."

Now how is this going to work out? Before one can even form an idea one must know what industries are acknowledged by those pursuing them to "no longer require all the support once needed." The Steel industry is probably one that no longer requires any tariff support; but will that support be surrendered? Will the Steel Trust be willing to allow British and German and Belgian steel to come in free of duty if they are allowed in return to plant American steel in Continental Europe free of duty? It is a question of profit and loss, but we fancy the balance will be on the side of retention of

the tariff duties. Moreover, the Steel Trust and any other American manufacturers can throw their products on British markets without any duties. They do not need to offer reciprocal advantages to us. On the other hand, we cannot tempt them to remove or abate their duties on our products, because we have nothing to offer them in return for the concession. We have already given them all we have to give. Had we, for instance, imposed a duty of twopence or threepence per gallon on petroleum, we might, under the Reciprocity policy, have bought large concessions from America in respect of our manufactures, now practically shut out by the Dingley tariff. But we did not—and we cannot. Great Britain is by far the largest customer America has, but America is nothing like so large a customer as she was to Great Britain before the Dingley tariff.

We would not like to say that Great Britain cannot benefit at all from the adoption of Reciprocity by the United States, but we are free to confess that we do not see how and where the benefit is to come in. It seems clear from the President's Message, and from the comments of the American press on it, that nothing is to be given up that America considers of any value in order to purchase entry into the foreign markets she covets. It seems a case of "one for you and two for me"—only more so. Still, perhaps, one may be justified in welcoming the Reciprocity movement as a step in the direction of freer trade all round. It is but a short step, yet it seems in the right direction.

Automatic Weaving Machines.

FEW persons acquainted with the true state of affairs will challenge the statement that a good deal of the success gained by our American rivals in the field of industry is due to the fact that they are employing, for the performance of very important portions of their work, ingeniously constructed machinery, executing with accuracy and unswerving loyalty the task entrusted to them, requiring but the smallest amount of care to remain in a fit condition, and being always ready for use at whatever moment they may be called upon to resume their labour. The only human assistance this machinery requires is of so slight a nature that in most cases a child could give it, while in other special cases the aid of a superior workman is needed, who is above the class of those who clamour for eight hours, and is anxious to do the best and give all his time, if necessary, to his employer, knowing that by so doing he is sure to promote his own interests.

We, on the other hand, are still continuing to have our work done by men who, "as a protest against the tyranny of employers," permit themselves to become unwittingly the tools of agitators, for whose maintenance they sacrifice, in times of work, part of their wages that could be far better employed for the benefit of their family, and at short intervals, at the agitators' command, throw up their work, sacrifice the whole of their income for many weeks, and meanwhile live on a part of their wages previously laid by, as they imagine, in order to be able to fight for their rights, but in reality to secure occupation for the very men whose tools they have become.

A manufacturer who has the misfortune to be in the hands of men so absolutely dependent upon leaders that are the avowed antagonists of the employers of labour must, of course, be at a serious disadvantage in a contest with rivals who have reduced the element of irreliability and uncertainty in their workshops to a minimum.

One of the branches of industry in which the emancipation of the workman will bring considerable profit to all concerned is the weaving industry, which in its modern form was practically created in this country, but which, owing to the employment of automatic machinery by our rivals, is in danger of being no longer able to hold its own.

Cartwright's loom secured for Great Britain's weaving industry a position which for over 100 years remained beyond attack, and until quite recently all improvements in this famous machine tool were of but little importance. During the past few years, however, the condition has greatly changed since the appearance of the "Northrop" loom, placed upon the market by the "Draper Loom Co., U.S.A.," has displaced the centre of progress in weaving and transferred it to the other side of the Atlantic; and the worst of it is, that Northrop, the inventor, was an English mechanic who had received his training at the loom works of Messrs. Hattersley & Sons, at Keighley, in Yorkshire, but left his native country, bitterly conscious, no doubt, of the fact that under existing conditions there was little hope that a workman would profit by initiative and special ability, since his wages were regulated by the "union," and extra zeal and efficiency were treated by his comrades as a crime against humanity.

The automatic loom was invented by Northrop at the time when he was in the employment of the American company above-named, which speedily popularised it, and made it highly profitable for both the inventor and his employers, as will be realised when it is stated that 80,000 of these looms are in use at present in the United States, and several of them on the Continent. What Northrop's chances would have been had he remained in his native land may be guessed from the fact that the number of Northrop looms here is represented by the figure 1; and even this has not its place in a factory, but was shown as an exhibit; and to this, we understand, its inglorious existence is confined.

In the United States the speedy success of the new loom has given birth to further improvements, and at this moment our competitors continue their industrial warfare in the field of the weaving industries, with the additional weapons of the looms of the Naiuman Loom Co., the Crompton Loom Co., and several others. Meanwhile, however, there are signs of an impending change even in the British weaving industry, and of late there has appeared among us the Ross's Automatic Loom, Belfast, that of the Crossley Automatic Loom Co., Manchester, and Hattersley's Automatic Loom. Let us hope that these automatic looms are the forerunners of other inventions that will give both liberty to employer and workman alike, and secure to the latter, not the wages the union guarantees to him, but wages dependent upon his ability and efficiency, thus rendering profitable his self-improvement and holding out to him the hope of rising higher and higher in his trade, should he show ability and energy above that of other workers.

Efficient Sewage Oxidation.

THE problem of efficient sewage treatment, though it has been in the focus of scientific attention for a considerable period of time, has by no means as yet found that practical solution which, theoretically, seems to be attainable. There have been vast improvements—ever since students of science began to be interested in the subject—and by modern methods the sanitary condition of great towns, compared with that prevailing as long as the primitive treatment of sewage customary in earlier times was still in vogue, has wonderfully advanced. The great hopes, however, that were raised at the time that the bacteriological treatment was first experimented with have so far not been fulfilled. Notwithstanding the fact that trials based on the principles underlying this treatment have been going on many years, there has been very little advance. We cordially welcome, therefore, the appearance of a small pamphlet from the pen of Mr. F. Wallis Stoddart, F.I.C., F.C.S., of Bristol, who has obtained a conclusive success, and, what is most satisfactory, has obtained it, not by fanciful modifications, but by logically adhering to those conditions that theoretically are the cause of the destruction of the noxious matter contained in sewage. This pamphlet is entitled "The Con-

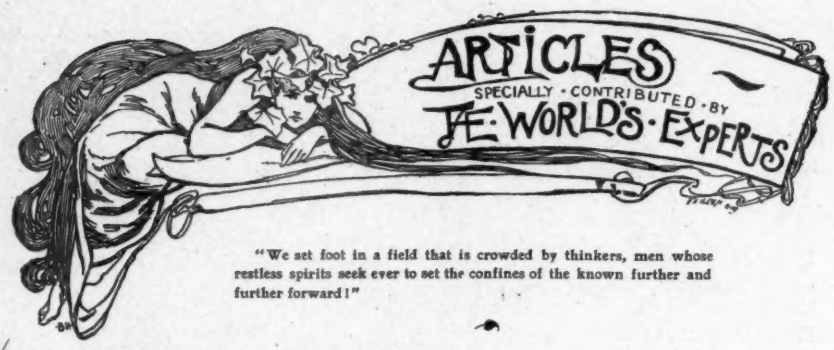
tinuous Sewage Filter," and is introduced by a few remarks on the part of its author explaining the sense in which the terms "filter" and "continuous" are used.

Mr. Stoddart's success in the treatment of sewage is due to the fact that he kept in mind that in a sewage filter the purification is accomplished by "aërobic" organisms which for their existence depend upon a sufficient supply of oxygen, and that these beds require aëration at given intervals, as well as during a period of prolonged rest, so as to be able, after being repeatedly immersed in sewage devoid of oxygen, to recuperate. Very frequently persons in charge of sewage works seem to have but one aim, namely, to get out as much work as possible of these bacteria, and, sooner or later, they meet with the natural result, *i.e.*, that these useful organism have perished for want of strength due to lack of oxygen. Mr. Stoddart has fully recognised the necessity of a constant supply of oxygen in order to obtain efficiency from aërotic treatment of sewage. For this purpose he constructed a bed of washed clinker 1½ in. cube, or even larger. Over the surface of this bed the sewage, after having passed through a septic tank, is dropped in an uninterrupted spray, coating every stone and particle with a firm film. Among the precautions necessary to obtain the best results is the one that the rate of supply must not be so fast as to water-log any part of the filter, and all interstices must be kept quite open.

From his experiments it is seen that a very large amount of sewage, up to 10,000 gallons per square yard per day, can be passed through a filter of this kind, consisting of particles ranging from 2 ins. to 3 ins. in diameter, without water-logging. The distribution of the sewage in the shape of a spray or rain, forming thin films on the surface of the clinker, was a problem not solved without difficulty, nozzles or small orifices being obviously useless, owing to their liability of clogging up in a short time. It was solved, however, by Mr. Stoddart in an ingenious and thoroughly practical way—namely, by placing across the top of the filter a row of zinc gutters of V-shaped section forming, so to say, a roof. Above these gutters, and at a right angle to their length, runs a distribution channel, exactly level, into which the sewage enters, and, when overflowing the edge, falls into the gutters in equal quantities. These gutters are closed at the ends, but have notches cut in their edges, and are provided with a row of metallic points at short distances from each other along the bottom; in fact, there are 360 such points to each square yard of filter. This arrangement, simple as it is, is thoroughly practical, as the liquid keeps falling off these points in small drops, which do not lose their efficiency even after they have become coated with a mucilaginous layer.

The first continuous filters of the kind here described were laid down at the sewage works near Bristol, covering an area of 29½ square yards, filled with 6 ft. of washed clinker, originally of small size, but later replaced by clinkers of 2½ ins. Through this filter the whole sewage of the district was served on May 28th, 1901, being 46,000 gallons, or 1560 gallons per square yard of filter per 24 hours. The final analysis of the affluent, made September 12th, 1900, proved very satisfactory, and the rate of flow was shown to be 5,000,000 gallons per acre per day of 24 hours.

To be able to thoroughly purify sewage at that rate per acre per bed is a remarkable success, considering that, as far as we know, no other system has ever been claimed even one-fifth of this efficiency. Were the figures given only in the author's pamphlet, those who do not know the author's reputation might hesitate to accept their accuracy, and attribute them to that natural enthusiasm derived from a successful solution of a difficult problem, which very frequently is not conducive to scientific exactitude. The results above stated, however, were verified during the Local Government Inquiry held at Kingswood, on March 6th, 1901, which removes all doubt, and permits us to congratulate Mr. Stoddart on an achievement due to sound scientific method, that brings us considerably nearer the fulfilment of the earlier expectations based on the bacteriological treatment of sewage.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Production of Electrical Energy from Carbon.

By W. R. COOPER, B.Sc., A.M.Inst.C.E., A.M.I.E.E.

At the beginning of the past year, in connection with the commencement of a new century, Edison directed attention to this problem in the following words: "I think the most important line of investigation is the production of electricity direct from the combustible." Undoubtedly the subject is a very important one, and from the scientific point of view it is of the greatest interest; but there is often only a vague impression of the precise commercial value of a carbon-consuming battery, supposing one to be discovered in which the carbon is efficiently consumed and the cost of the other constituents is small.

It is on account of the inefficiency of steam plant that attention has been given to the possibility of generating electrical energy direct from fuel. The combustion of 1 lb. of good coal gives rise to about 11,000,000 ft.-lbs. of energy, so that a perfectly efficient steam plant should require only 0·18 lb. of coal per i.h.p. hour. Taking 2 lbs. of coal per i.h.p. hour as a good result in practice, it is seen that the efficiency is only about 9 per cent., and, owing to various causes, this result cannot be very much improved.

In steam-driven plant there are several transformations of energy, each of which gives rise to a loss. For example, there is, first of all, an inefficiency in the transference of heat supplied by the combustion of the coal to the water in the boiler. This is followed by condensation or radiation losses in steam pipes, to which may be added losses in auxiliaries. Further, there is a thermodynamic limit upon the possible efficiency of the steam engine; and there is in addition the inefficiency of the steam engine as regards steam consumption. Finally, there is the combined mechanical and electrical efficiency of the engine and dynamo. The gradual loss of energy in this process of generating electricity is shown graphically in Fig. 1, and it is seen that even when the best results obtainable in practice are assumed the loss is very heavy, giving an efficiency of only something like 10 or 12 per cent. Under the ordinary conditions of running a generating station the losses are much more serious, and the efficiency is not more than one-quarter to one-half this figure.

In the case of a battery, on the other hand, there is only one transformation of energy—viz. from the chemical to the electrical form—and therefore a higher efficiency is to be expected, if only on that

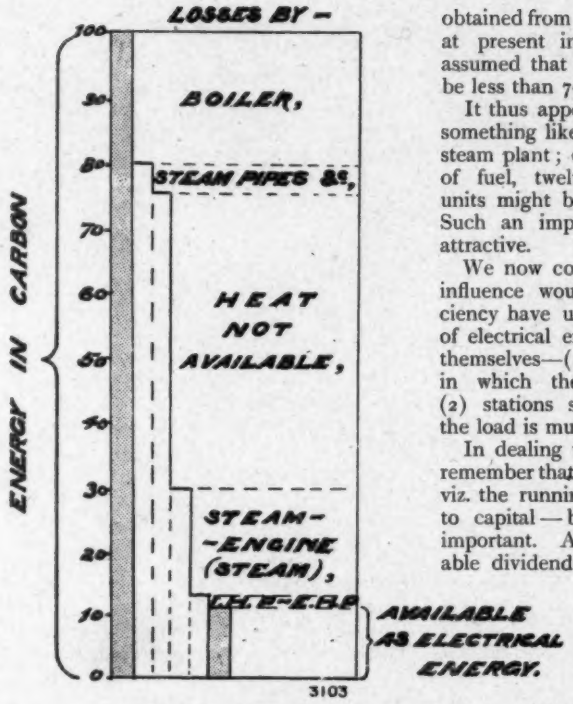


FIG. 1.—DIAGRAM SHOWING LOSSES IN GENERATION BY STEAM.

account. Indeed, the efficiency might reach a very high figure under suitable conditions, for there is no limitation such as that imposed by thermodynamics in the case of the steam engine. But there are certain causes of loss which must always exist to a greater or less degree, such as polarisation, internal resistance, local action, and incomplete utilisation of materials. The extent to which these will affect the final result must depend, of course, upon the design of the battery, and one of the objects in view will be to diminish these losses as far as possible; in fact, unless these are kept below a certain figure the battery becomes of no commercial value. Unfortunately, no carbon-consuming cells deserving of the name have yet appeared, and so it is impossible to give a definite limit for the above losses; but judging from the results obtained from the various kinds of batteries at present in use, it may perhaps be assumed that the mean efficiency will not be less than 70 to 75 per cent.

It thus appears that a battery might be something like twelve times as efficient as steam plant; or that for a given quantity of fuel, twelve times the number of units might be generated by the battery. Such an improved result is, no doubt, attractive.

We now come to the question, What influence would such an increased efficiency have upon the cost of production of electrical energy? Two cases present themselves—(1) Stations supplying light, in which the load is very variable; (2) stations supplying power, in which the load is much more steady.

In dealing with costs it is necessary to remember that these consist of two parts—viz. the running costs and the costs due to capital—both of which are equally important. A company must pay a suitable dividend if it is to be considered a successful concern, and a local authority must annually set aside a very fixed percentage for interest and sinking fund. There is often a tendency to regard the running costs as more important than the capital charges. This may be due perhaps to the fact that running costs frequently lend themselves to improvement; or, at least, they are always under the control of the managing engineer. Capital, on the other hand, is expended once for all, and the costs due to this capital cannot be altered, unless it is by improving the load factor so as to really make the capital more productive. There is an abundance of figures giving the analysis of running costs of the various electric lighting stations in this country, and these are of great value to all who are concerned with central stations, and they serve also to increase the efforts of those in charge to diminish these costs as far as possible. But figures showing the capital cost per kilo-watt, units generated per kilo-watt, and—in the case of local authorities at least—the earnings per unit required to pay the costs

due to this capital expenditure, would also be of great interest. The first set of figures depend largely upon the management; the second set chiefly on the design of the station. It need scarcely be said that capital expenditure is dependent to a considerable extent upon the character of the locality, and that heavier capital outlay is often incurred in order to obtain low running costs, but in a well-designed station the two should be suitably balanced, so that neither side is sacrificed to the other.

An average figure for the cost of a complete central station and network of mains is about £100 per kilo-watt, of which £55 per kilo-watt is spent on land, buildings, and plant, and £45 per kilo-watt is spent on mains. The dividend paid on this capital may, of course, be anything in the case of a company; but if the station is worked by a local authority, then a fixed sum, amounting at the present time to about 6 per cent, must be set aside annually to repay the loan. In other words, every kilo-watt of plant must earn £6 per annum on account of capital charges alone. The same thing practically holds good for a company if it is successful, the only difference being that in the event of a profit not being made above the running costs the shareholders, in the case of a company, fail to receive anything, and the ratepayers, in the case of a municipal undertaking, have to pay the deficit.

In lighting-stations the number of units sold per kilo-watt per annum is frequently about 600. Taking a municipal station, therefore, as a standard, the cost per unit of the capital charges is $\frac{6 \times 240}{600}$, or 2·4*d*. This amount may be subdivided into two parts—viz. 1*s*. 3*d*. due to the station and 1*s*. 1*d*. due to the mains.

The costs of generation and distribution may be taken as 3*d*. per unit sold, of which about 1*d*. is accounted for by the coal bill, the price of coal being, say, 20*s*. per ton. A lower figure is frequently obtained, but in such cases the stations are large, or are run under exceptional conditions. We have, therefore, the following figures for the total costs:—

Costs of generation	Fuel	1*d*.	
	Other items ...	2*d*.	
			3*d*.
Capital charges	Generating station	1·3*d*.	
	Mains	1·1*d*.	
			2·4*d*.
	Total ...		5·4*d*.

The above figures show that although the cost of coal is an important matter, it is by no means a predominating factor in the total cost. Moreover, the cost of fuel is frequently lower than the figure here given, figures below 0.5*d*. per unit being not uncommon. Taking these costs, however, as they stand, it is seen that, of the total, the coal amounts to 18·5 per cent., which thus represents the saving that would be effected if the coal could be obtained for nothing. If a battery consumed only $\frac{1}{12}$th the amount of fuel at present required, the saving would be 17 per cent. This saving is considerable, but it is not sufficient to cause the revolution which many people seem to have anticipated as the result of a suitable carbon-consuming battery. Consequently if any great saving is to be brought about it must be effected on some of the other items. Possibly something might be saved in wages, but a definite opinion cannot be expressed without experience.

Let us now turn to the capital charges. The amount on account of mains is 1·1*d*. Unfortunately, this cannot be reduced by any change in the method of generation. The only thing to be done is to generate more units for a given expenditure on mains. There are two ways of doing this. The first is to raise the pressure of supply, so that the number of kilo-watts transmitted for a given current density or given percentage drop in mains is greater. Under existing regulations this limit has nearly been reached, and therefore we cannot hope for much improvement. Even if the Board of Trade allowed a higher pressure than 250 volts to be used in consumers' houses, it would be impossible to take advantage of it on account of the difficulties experienced in making high-voltage lamps, unless it be that lamps of the Nernst type could be made of sufficiently low candle-power for high pressures. Of course, two lamps might be run in series,

but there are obvious objections to such a method.

An improved efficiency in the lamp itself does not help us here. That would decrease the cost to the consumer for a given amount of light, but the cost per unit would remain the same. Consequently the maximum number of units for given mains would remain the same and the number sold per annum for a given lamp connection would diminish. The only gain to the company would be that the number of consumers would largely increase owing to a cheaper supply of light, and the total number of units sold would therefore rise instead of fall.

The other way of lowering the capital charge on mains (and on plant as well) is by securing a load which continues for a longer time—in other words, by improving the load factor; for example, by supplying public lamps, or a tramway system. The importance of the load factor is readily seen; for example, if every kilowatt supplies 1,000 units per annum instead of 600 the capital charges fall at once to 1·45*d.*, and there is a saving of 0.95*d.* This figure of 1,000 units per annum per kilo-watt is seldom exceeded in a lighting-station, even when the load factor is improved by a tramway or by public lighting.

We must, therefore, conclude that mains form a heavy charge on an undertaking, and one which, unfortunately, there is not much probability of reducing. In stations of ordinary size, such as we are considering, and which distribute over a comparatively small area, this charge is serious enough; but in the case of stations distributing by alternating currents at high pressure over a large area, such as those required in the power schemes which have recently come forward in this country, this charge is far more serious, because it has to be taken in conjunction with heavy light-load losses, chiefly due to capacity. In fact, large power schemes may possibly be considerably hampered unless overhead lines are permitted. Since in such schemes it is generally proposed to supply only in bulk—or, in other words, to large consumers, who would otherwise generate for themselves—it is essentially a question of being able to reduce the combined cost of generation and distribution below the cost at which the consumer can generate without distribution, it being assumed that his cost of distribution is negligible. The cost of generation by a large company should certainly be small, but the total cost may be too high to compete profitably unless the cost of distribution is also small.

It is a different matter, however, with the capital expenditure on the generating station. This would probably be diminished if a suitable battery were discovered. The buildings would certainly cost less, and a battery should be cheaper than steam plant. Assuming the total cost to be one-third less, then the saving would be about 0·4*d.* per unit. Adding this to the possible saving in fuel, the total amounts to about 1·3*d.*, or 24 per cent. There might also be a saving in wages; but, on the other hand, it is quite possible that the electrolyte and the electrodes opposed to the carbon might run into considerable expense, and might annul a great part of the saving otherwise effected.

We may conclude, therefore, that in the case of stations supplying light the saving would not amount to more than 25 per cent. The case is different with stations supplying power, because the load factor is very much higher. Consequently the capital charges are much less. The other items are also much reduced, but the cost of fuel is not diminished to the same extent, and thus it becomes relatively of greater importance, and any saving which is effected is equally more important.

On turning to a consideration of the problem itself—viz. the production of a carbon-consuming cell—we find that there are a great many difficulties. Coal is, of course, the material that we wish to deal with, because it is the most plentiful kind of fuel which we possess. But coal in itself cannot be used; it is a non-conductor, on account of the hydro-carbons which it contains. Consequently it must be carbonised, or converted into coke, before it is fit for use. There is no objection to so doing because the by-products obtained in the process are of great value. We must, therefore, consider coke, or carbon as the material with which we have to deal.

Unfortunately carbon is a comparatively inert substance. Unlike the metals, it does not form salts. In most primary batteries zinc is used as the positive plate, or the plate which passes into solution, and it forms a salt when voltaic action takes place. If carbon is to be used instead of zinc it is necessary to find an electrolyte in which carbon is soluble, or in which a suitable reaction can take place. So far no solution has been found.

A second difficulty is that comparatively few of the compounds of carbon are electrolytes. In primary batteries, the electrolyte is always either a solution of a salt of the positive plate or else a solution of some body in which the positive plate dissolves to form a mixed electrolyte. But in the case of carbon the choice is very limited.

A third difficulty arises from the fact that voltaic action takes place by means of ions, or by the splitting up of compounds into two parts in such a way that these two parts act respectively upon, or pass to, the two plates of the cell. For example, in a simple cell consisting of zinc and copper in sulphuric acid the SO_4 combines with the zinc, while the H_2 is deposited on the copper. But, unfortunately, in organic compounds which are electrolytes the carbon is not an ion, the ions generally being compound radicles containing carbon, but not carbon alone, and therefore not of the simple form desired.

In voltaic cells the positive plate is always coupled with an element to which it is electropositive. Thus zinc is coupled with carbon, and carbon is then the negative plate. But if carbon is to be made the positive plate, then it is necessary to find an element or compound body to which it is electropositive. No metal, however, is available, though perhaps a suitable compound might be found—for example, an oxide—for such bodies are much more electronegative than the metals from which they are derived.

We are so accustomed to voltaic action taking place by the formation of salts, or bodies of that nature, that a mental difficulty is experienced in seeing the possibility of voltaic action by some other process. Even if carbon were to form salts, it would be preferable to employ an oxidation process on account of the large store of oxygen which we always have at our disposal. But the fact that the oxides of carbon are gases introduces a difficulty, because they are incapable of acting as electrolytes.

In dealing with this problem there are two main alternatives—one is to oxidise carbon to CO_2, and the other is to complete the oxidation of the lower oxide, or to convert CO into CO_2. The first alternative is preferable from the point of view of e.m.f., because the reaction includes the total heat of combustion of carbon and therefore gives the maximum e.m.f. But the second alternative opens up a completely different line of investigation, which might perhaps be the more productive of the two. In dealing with CO it is necessary to introduce it into one pole of a gas battery, oxygen being at the other pole. The great difficulty with gas batteries up to the present has been that no plates have, so far, been discovered which are capable of absorbing the gases with sufficient rapidity to supply current on a commercial scale. It appears to be essential that the electrodes should absorb the gases, so that voltaic action takes place, as it were, direct with electrodes of the gases themselves, possibly in a more active condition.

Of the various attempts which have so far been made to discover a carbon-consuming cell none can be said to be a success. This appears to be chiefly due to the want of appreciation of what is known as local action. It is too frequently assumed that if a chemical reaction takes place under ordinary conditions the same reaction will give rise to electric energy in a voltaic circuit. For example, zinc dissolves in sulphuric acid to form a sulphate, but the existence of this reaction is not a criterion of the suitability of zinc to form the positive plate of a voltaic cell. In fact, as is well known, ordinary zinc is unsuitable for use in a cell with an acid electrolyte on account of the excessive local action which occurs. The zinc is therefore amalgamated, and we then find that voltaic reaction takes place when the circuit is closed, but that

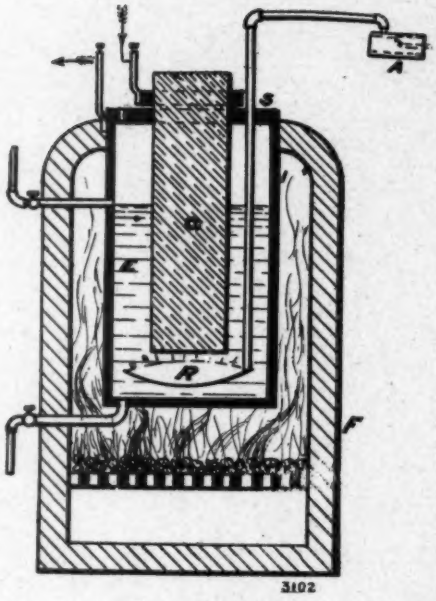


FIG. 2.—JACQUES CELL.

the same reaction does not take place under ordinary conditions with no voltaic circuit. In the same way zinc dissolves in a voltaic cell containing a solution of ammonium chloride as the electrolyte, although it does not dissolve if simply placed in a solution of that salt. In fact, it may be said that a reaction is unsuitable for voltaic purposes if it takes place under ordinary chemical conditions, because in such a case local action would be continually taking place, and such a cell would be commercially useless, even if capable of supplying electric energy.

An example of local action is seen in the experiment of Jablochkoff, who attempted to obtain a voltaic effect by placing carbon in fused potassium nitrate. Since the oxidation proceeds just as vigorously without the closing of any circuit, the method can give no good result.

The carbon-consuming cell which has aroused the greatest interest is that due to W. W. Jacques. In this cell a fused electrolyte is used instead of one that is liquid at ordinary temperatures, and consequently heat has to be continually applied. As shown in Fig. 2, the carbon *C* is immersed in fused caustic soda *E*; this is contained in an iron pot *I*, which also serves as the other plate of the battery. Air is blown into the caustic soda by the pump *A*, and is distributed by a rose *R* fixed just below the carbon. A furnace *F* surrounds the whole cell and keeps it at a temperature of 400 degs. to 500 degs. C. The carbon is oxidised by the air to CO_2, which mostly bubbles up through the electrolyte and escapes, it being said that the caustic soda remains practically unchanged. A certain amount of carbonate does, however, form, and impurities are also introduced from the carbon, so that the electrolyte becomes worthless after a time. The carbonate so formed may be diminished by adding a small percentage of magnesium oxide. The e.m.f. obtained is about 1 volt, and the current that can be generated is said to be very large compared with that produced by other cells of equal weight.

In this cell there appear to be many causes of inefficiency. For example, it is necessary to heat the electrolyte con-

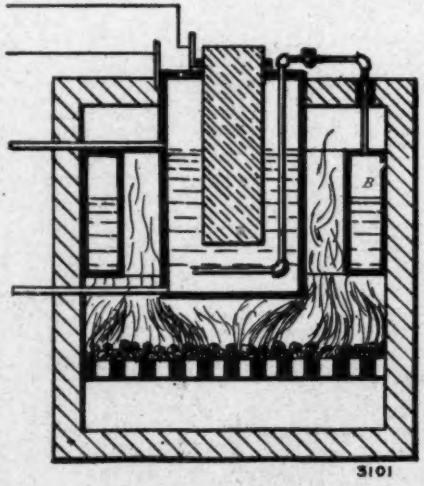


FIG. 3.—BLUMENBERG'S CELL.

tinuously to keep it in a state of fusion. Air must also be pumped through the electrolyte, otherwise the e.m.f. falls. On account of this stream of air local action must take place; in fact, the air appears to be wrongly placed, for the oxidising agent should be at a distance from the carbon. Lastly, the electrolyte is costly. Professor Elihu Thomson has stated that CO_2 does not escape when the cell is in action, but forms carbonate. If that is so, the life of the electrolyte must be short. On account of these various disadvantages, Mr. C. J. Reed has stated that the efficiency is as low as 8 per cent. In the case of a large plant the efficiency might be a good deal higher, but it is very doubtful if it would be sufficiently high to enable the cell to compete against steam plant.

Another cell of a similar kind, of which a section is shown in Fig. 3, is that due to Blumenberg. The chief difference is that steam, produced in the boiler *B*, is blown into the fused electrolyte, whereas air is made use of in the Jacques cell. The electrolyte is supposed to oxidise the carbon and to regain the lost oxygen by decomposing the steam.

Results are, no doubt, obtainable from these cells, but the extravagant claims made by Jacques are not likely to be realised. Cells containing fused electrolytes are more complicated than the batteries to which we are accustomed, and which contain electrolytic solutions at the ordinary temperature, because thermo-electric effects are also present. Consequently it may be that the electric energy obtained is not due to voltaic combination with carbon at all, or only in part due to the carbon. Indeed, there is a good deal of evidence in favour of the view that the e.m.f. is simply thermo-electric. In addition to this the cells so far produced seem to have been designed with a view to excessive local action rather than its avoidance. No useful result is likely to be attained without a true appreciation of the difference between ordinary chemical reactions and those which are voltaic.

W. R. Cooper.

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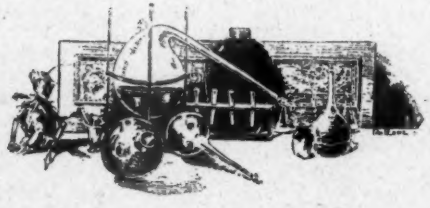

Protection versus Free Trade.

By JOS. C. NICHOLSON.

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IN the year 1846, and while the Third reading of the Repeal of the Corn Laws Bill was under discussion in Parliament, Mr. Disraeli said :—

> "It may be in vain now, in the midnight of their intoxication, to tell them that there will be an awakening of bitterness. It may be idle now, in the springtide of their economic frenzy, to warn them that there will be an ebb of trouble. But the dark and inevitable hour will arrive: then—when their spirit is softened by misfortune—they will recur to those principles which made England great, and, in our belief, can alone keep England great. They may then perchance remember, not with unkindness, those who betrayed and deserted, were neither ashamed nor afraid to struggle for the good old cause, the cause with which are associated principles the most popular, sentiments the most entirely rational—the cause of labour, the cause of the people, the cause of England."

Mr. Disraeli on this occasion spoke of principles which had up to that time been the foundation of England's greatness, both as an agricultural and manufacturing nation, principles so true and strong that their influence has even down to the present moment contributed to save this country from absolute commercial defeat.

It is on the principles of National Trade Protection that other countries, which 50 years ago were our markets, are now surpassing us as manufacturers, and, not only that, but have reversed the conditions then existing to such an extent that England has become the dumping-ground of their surplus manufactures, and our colonies every day are buying more from them and less from the mother country. As a sample of this state of things I give the following figures from the official report of the Canadian Dominion Government, showing the imports into Canada for the seven years from 1893 to 1899 :—

Year.	From Great Britain.	Per cent. of total.	From the United States.	Per cent. of total.
1893	£8,505,868	36·9	£10,467,959	45·4
1894	7,407,192	34·0	10,149,218	46·5
1895	6,211,866	30·8	10,035,800	50·0
1896	6,564,901	31·1	10,705,878	50·8
1897	5,880,037	27·6	11,404,468	53·5
1898	6,408,692	25·4	14,964,984	59·2
1899	7,386,264	24·8	17,693,434	59·2

It will thus be seen that while in 1893 Great Britain had 36·9 per cent. of the total imports of Canada in free and dutiable goods, her share of Canadian imports in 1899 had fallen to 24·8 per cent. of the total. On the other hand, the United States increased her share from 45·4 per cent. in 1893 to 59·2 per cent. in 1899. And yet the products of Great Britain are admitted to Canada under the preferential tariff at a rate of duty 33⅓ per cent. lower than that from the United States or any other country.

It is claimed by Cobdenites that Great Britain has prospered by Free Trade. There, no doubt, was a great increase of trade during the first quarter of a century after the repeal of the Corn Laws and the removal of other trade protective fences, but it should not be lost sight of, that until other nations built up their manufactures and came into strong competition with us, we were living under a condition of the most absolute natural protection that was ever known in this or any other country. But to-day the conditions are changed, and to the serious detriment of the interests of this nation. It is very patent that at the present time Free Trade doctrines are upon their trial, and it should not be overlooked in hearing evidence for and against them that upon the real test to which those doctrines are subjected every essential prediction made

by Richard Cobden and his associates, as to their effect upon the industries of this country, have proved false; and that Mr. Disraeli and other Protectionists of his time fully realised the disasters which the change of policy would bring upon the English people. The tenant farmers soon found out how they had been deceived by Cobden. He declared, in 1844, that "Free Trade in corn is the very best way to increase the production at home, and would compel the application of more capital and labour to the soil of this country"; again, in the same year, Mr. Cobden declared that "Free Trade will make the agriculturist of this country capable of competing with the farmers of any part of the world."

There has never been in English politics a prophet whose predictions have proved so false; the propaganda of Cobden was a most cunningly devised scheme to attack the landowners and to arouse the prejudice of the people against them. He predicted that other countries would follow the example of Great Britain and throw their ports open to the produce and manufactures of the world; but whenever the statesmen of America, Germany, or other countries have listened to the voice of the charmer or his associates, they have always found that legislation in that direction only brought commercial and financial ruin in its train, and I cannot do better in this connection than quote the words of Bismarck after his country had suffered under such an experience, when he declared that he "held Free Trade to be altogether false as an absolute principle."

The great cry of the Cobden school is "cheapness," and it is a wonder that the working man of this day does not see through it, and ask himself how it is that his American brother receives double the wage he does, and is still able to send his work over to this country free of duty to compete against him. If he complain on this score, he will be told that he gets his bread cheap, as if 10 to 15 per cent. on grain in this day would make any appreciable difference to the working man's loaf, especially when he would have a share, through increased and more regular wages, in supplying the manufactures required in his own country. There is a generally accepted theory, which the modern political economist has drunk in as pure milk from the old Free Trade cow, namely, that if a protective tariff were established in this country it would raise the price of manufactured articles to the consumer. I can only say that the experience of protecting countries has been quite the contrary, and if this was not so they would not at the present time be in the position to compete with us so successfully. It is pointed out that the volume of our trade increases from year to year, as if it were no consequence what the relative amounts of imports and exports were, and as if it were just the same to the trade and wealth of the country when imports increase and exports decrease as when exports increase and imports decrease. Imagine a man in business flattering himself that his sales and purchases week by week were increasing in their added volume without making sure that the former were considerably in excess of the latter. This is Free Trade financing. It cannot be disputed that England's commercial supremacy amongst the nations is being seriously challenged, and has already begun to decline under her Free Trade System and the competition from Protectionist countries. At a dinner given by the master cutlers of Sheffield in 1885, Lord Granby said:—

> "With a small duty on corn I would put a heavy duty upon all manufactured articles. I would admit raw materials free. I would take off the duty on tea and sugar, and above all the poor man's tobacco."

In these days of increasing armaments and a costly war in South Africa, the demands of the Chancellor of the Exchequer are increasingly great; and while he has no compunction in suddenly imposing an export duty on coal and thus seriously dislocating the foreign trade in that mineral, yet the doctrine of Free Trade is so sacred and the prejudices of the Manchester school are so strong, that he shrinks from imposing any duty on a single article coming into the country from abroad, the imposition of which would at once bring revenue to the Exchequer

and stimulate the home manufacture of that article by giving it some little advantage over its rival from abroad.

Perhaps there has never been in this country so strong a desire as at present exists to bring about a closer bond between the various States, Colonies and Dependencies scattered over all parts of the globe and the Mother Country; and whether or not the recent legislative union of the six Colonies of Australia into a United Commonwealth, will be followed some day by a greater legislative union of all parts of Greater Britain, still the goal we have before us at present is the consolidation of our commercial system so that as far as possible there may be free trade within the Empire, with a substantial protective tariff imposed by the Imperial and Colonial Parliaments against the products and manufactures of all other countries. Thus a mutual trade interest would be created which would act as a welding-bond to hold together the greatest Empire the world has ever seen.

Jos. C. Nicholson

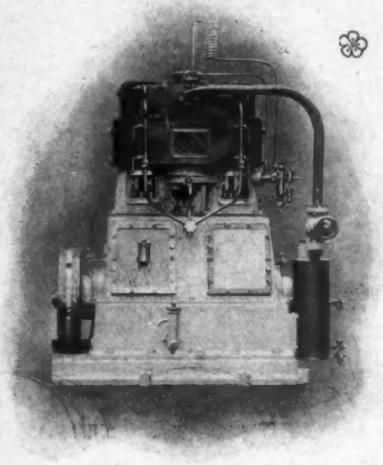
THE Editor of FEILDEN'S MAGAZINE, whilst not absolutely pledging himself to any rapid revolutionary change, is of opinion that there should be no longer delay in the pursuance of a vigorous and aggressive line of action with a view to the modification of our fiscal arrangements, called for by the altered conditions of the times. He therefore invites, as a preliminary, criticisms and opinions from his numerous readers, with a view to a campaign which can rightly be described as of truly pressing National importance.

Important articles on the subject will appear in succeeding issues of FEILDEN'S MAGAZINE.

High-Speed Engines.

By H. J. DALES, A.M.Inst.C.E.

(Continued from page 576, Vol. V.)



PROBABLY the most correct appreciation of the possibilities of high-speed engines is to be obtained from the consideration of the principles which control their design. First of all, the matter of safety must be provided for, so that the practical risks of running such engines may be reduced to a minimum, both in regard to the personal safety of the attendants and to the commercial aspects of uninterrupted work. For this purpose the strength and margin of safety of the piston line in particular should be carefully ascertained.

The chief point to be considered in the design of this line is uniformity of strength of section throughout all its members, piston rod, connecting rod, crosshead bolts, and connecting-rod bolts, not so much in regard to size as in actual strength at each point. For the correct estimation of these sections, of course the accurate strength of the material to be used must be known—in fact it is desirable to have the whole of the testing machine particulars, viz., the extension up to the point of limit of elasticity, the limit of elasticity in pounds per square inch, the limit of extension, the ultimate strength in pounds per square inch, the reduction of section, and the length of failing part.

With these particulars there is no difficulty in designing a piston line with a definite margin of safety for any given speed of rotation.

The limit of elasticity is the point upon which the strength of the piston line depends, as it indicates the point at which the line would begin to fail.

The relative quantities of the limit of elasticity and ultimate strength are required for proportioning the sections of the fastenings to those of the body or long parts; otherwise the ultimate strength is of no moment, and any design made on its basis alone would be delusive.

It is obvious that if the full benefit of the elasticity or extensibility of the metal is to be obtained for minimising the effect of shocks, and at the same time preserving the fit and solidity of the fastenings, the fastenings and long parts should be so proportioned to each other that the fastenings should be capable of rupturing the long parts without damage or alteration to themselves; and this is to be done by making the relative sections equal inversely to the limit of elasticity and ultimate strength of the material. To make this clear, the case of a big end bolt which was tested to destruction may be considered. This was made from best Yorkshire iron (Farnley), which, as will be seen, possessed remarkable properties of extensibility. The dimensions of the bolt (Fig. 1) were $1\frac{1}{8}$ in. diameter in the shank or reduced part, $1\frac{3}{8}$ in. on the largest diameter, and the screw thread was $\frac{1}{16}$ in. deep, making the reduced diameter at the bottom of the thread $1\frac{1}{4}$ in. These sizes made the sections available for strength as 4 in the shank and 5 in the screwed part, at bottom of thread. The nut was placed about 5 threads from the inside end of the screwed part, leaving them within the strain, and the bolt was pulled

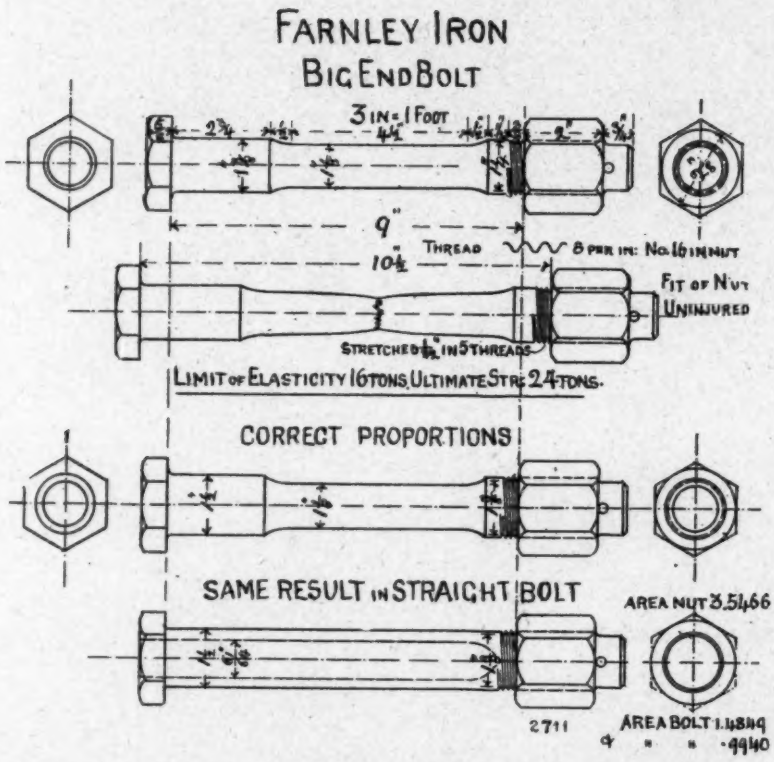


FIG. 1.—DIAGRAM SHOWING LIMIT OF ELASTICITY AND EXTENSIBILITY OF FARNLEY IRON BOLT.

asunder. The rupture took place in the reduced shank, after stretching 1½ in. in 4 in. at that part; the section was reduced to 50 per cent. of its original size. Now, although no flaw or damage could be detected in the thread within the position of the nut, it had stretched and taken a permanent set to such an extent ($\frac{1}{32}$ in. in 5 threads) that the nut would not go any further up the bolt than it had stood in the testing machine, and it was plain that for absolute safety the proportions were not correct. The limit of elasticity was 16 tons per square inch, and the ultimate strength 24 tons, which were as 2 to 3; and these should have been the proportions of the section of the shank or reduced part to that of the bottom of the screw thread, which would have made the bolt 1⅛ in. in the largest diameter, 1⅜ in. in the bottom of the thread, and 1⅛ in. in the shank. In testing a bolt of such correct proportions in the same way, the shank would have been ruptured without in any way damaging the threaded part. The fit of the nut was not affected in the least. The same result could, of course, be obtained by drilling up the bolt, and greater length for elasticity at the same time obtained in a case where a bolt must fill, or partly fill, the length of the hole in which it is fitted. It is a very dangerous practice to trust to rule of thumb or to copy others in providing for the strength of the piston line of a high-speed engine, the forces generated being very different

and much in excess, especially that of inertia of those in large engines.

For instance, seeing that the inertia of a line increases as the square of the number of revolutions, obtaining 600 ft. per minute from an 8-in. stroke—which is often and easily done—produces strains due to inertia six times in excess of those produced, weight for weight, from the same piston speed obtained from a 2-ft. stroke, after allowing for the difference of radius of the cranks. Of course the weights of two such lines, pressure for pressure, would differ somewhat, but not so much as might appear, for the fastenings would be pretty much the same, as well as the heavy parts of the piston; and the extra length would be in the small part of the rods. A margin of strength of six times at 150 revolutions per minute would be no margin at all at 450 revolutions, and whereas the former would be quite safe, the latter would be highly dangerous.

A most important point in designing the strength of a piston line is to bear in mind that the effects of a stress suddenly applied has double the effect of a stress gradually applied, so that testing-machine strengths must always be halved when reckoning for the available strength of the material of a piston line as regards the effects of inertia. In making these statements there is no intention of playing the alarmist, and for the purpose of showing how very ample a margin of safety can be obtained in engines of the class under notice by attending in an intelligent manner to the principles involved, the accompanying diagram has been (Fig. 2) made.

The drawing represents a practicable piston line of proportions such as advocated, and assumed for the sake of simplicity in illustration to be made of all the same metal throughout. An inertia diagram is drawn to a scale which represents the limit of elasticity of the section of the long parts taken at half the testing-machine strength. The stroke of the example is 8 ins., and the weight of the line is computed at 192 lbs. Two sets of lines are shown, one to represent the limit of elasticity of crucible steel as the strongest metal which is likely with ordinary construction to be used, and the other set represents the limit of elasticity of mild steel as the more ordinary constituent.

The computation shows that at 1,575

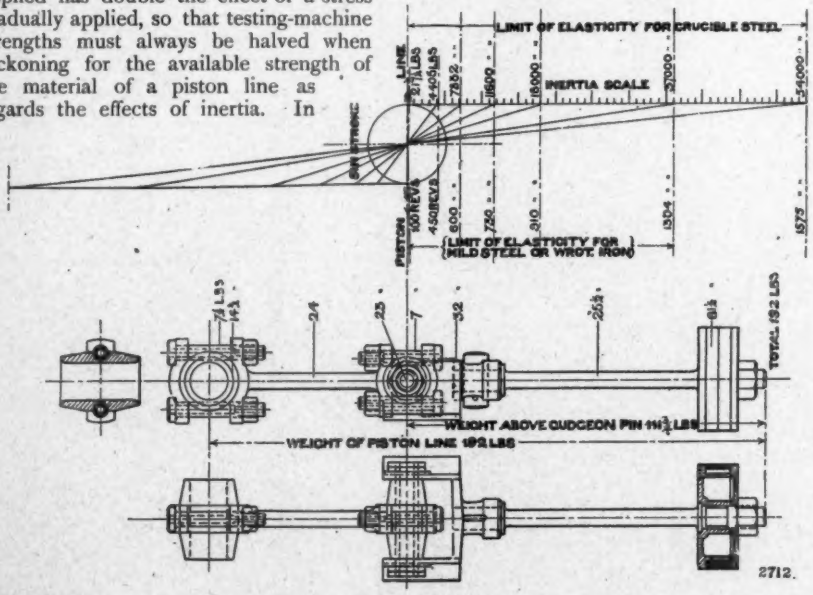


FIG. 2.—DOUBLE-ACTING PISTON LINE.

revolutions per minute of an 8-in. stroke, and with a weight of piston line of 192 lbs., the limit of elasticity of crucible steel (taken at 54,000 lbs., or half the testing-machine strength) would be reached, while at 910 revolutions there would be a margin of three times for the same material, or six times on the testing-machine limit of elasticity, and at 600 revolutions there would be a margin on this reckoning of nearly 14 times, showing very clearly that an engine having such a piston line is practically absolutely safe. These figures are for crucible steel construction, and exhibit the limit, so to speak, of possibility. When those for mild steel are taken, it is seen that the limit of elasticity would be reached at 1,304 revolutions; a margin of three times at 730 revolutions; at 600 revolutions the margin would be over $4\frac{3}{4}$ times, and at 450, $8\frac{1}{2}$ times on the half testing-machine limit of elasticity, or on the full testing-machine strength the margin would be respectively 2, 6, 10, and 17 times, which still gives practically perfect safety at 600 revolutions per minute, which may be considered the outside speed ordinarily for an 8-in. stroke. As before stated, the ultimate strength alone of a metal is no gauge of the margin of safety, as the proportion which it bears to the limit of elasticity varies in different qualities and makes of metal from 200 to 150 per cent. It is the point of stress at which a change takes place in the metal which has to be considered by the designer, and not that at which it is destroyed.

It is perhaps scarcely necessary to mention that if there are any dead weights in the piston line which are in proportion more than those in the example, either the speeds or margins would be lowered.

An easy method of ascertaining the inertia of the piston line is to consider the whole weight of the same as concentrated at the centre of the crank, and then finding the centrifugal force of the mass at the speed required, which is equal to the inertia. ·00034 lb. is the centrifugal force of 1 lb. at 1 ft. radius at one revolution per minute, and centrifugal force increases as the square of the number of revolutions per minute. (For exact calculation, of course, allowances would be made for any given length of rod on both out and in strokes.)

Therefore the example taken with a weight of piston line of 192 lbs., an 8-in. stroke, and a speed of 600 revolutions per minute, would work out as follows:—

·00034 lbs. × 192 lbs. × ·3333 ft. radius × 600^2 = ·00034 × 192 × ·3333 × 360,000 = 7832, which is centrifugal force or inertia in lbs.

To find the speed which will have an inertia equal to the limit of elasticity (half testing-machine strength) of the piston line, or the weakest part of the same, reference may again be made to the illustrated example. Taking the material as crucible steel, with a limit of elasticity of about 24 tons testing-machine strength, and an area of section of that part of the piston line referred to of 2 sq. ins.; by the rule of taking half the testing-machine strength, for resisting sudden shocks, there would be about 24 tons available strength for calculation. This amount in the illustration is roughly stated at 54,000 lbs., which is represented to scale by the longest inertia line. The scale of the diagram is $\frac{1}{16}$ in. to 1,000 lbs. By finding the inertia of the piston line at 100 revolutions, which in the example is 217·57 lbs., a divisor for the 54,000 lbs. is found, and by finding the square root of the quotient, the speed in hundreds of revolutions is arrived at thus—54,000 ÷ 217·57 = 248·19, and the $\sqrt{248}$ = 15·75 approximate; so that 1,575 revolutions would be the speed corresponding to the limit of elasticity (half testing-machine strength) of the piston line illustrated.

Crucible steel is taken as the strongest material which is in any case likely to be used for a piston line, and to illustrate the limit of speed for an 8-in. stroke without very special construction.

The maintenance of the longest fastening possible, such as in cotter holes, is of the utmost importance in a piston line, by reason of its greater elasticity than a short fastening, such as a screw thread. One of the reasons why a cotter hole seldom pulls out, while a screw thread most often gives way, is that the shock in the first case is distributed through the stretch of

two or three inches of metal, while in the case of a screw thread it has to be borne by the bottom of maybe one or two threads—say, perhaps, $\frac{1}{16}$th of an inch of length—and is consequently, as a matter of work, inversely greater in the short length. Altogether, the design of a piston line in this class of engine is a very different matter to that of a slow engine; and the latter class of experience, as will be seen, is very likely to be at fault if not backed by the necessary special considerations. In many other points the difference in the two lines of practice is very great.

A point of considerable interest in the matter of elasticity of a piston line, when subjected to a strain which is equal to the limit of elasticity of the material, is the amount of that elasticity. From recent experiments on annealed crucible steel made for ascertaining the above point it was found that the modulus of elasticity was 14,500 tons per square inch, which corresponds with an extension $\frac{1}{1000}$ in. in one inch of length at a strain due to 14·5 tons per square inch. Applying this to the example shown by the diagram, in which the reduced parts are 45 ins. long, and taking 12 tons per square inch in tension on the metal as the limit of elasticity (half testing-machine quantity), an extension of the line due to the stretch of these would be $\frac{12}{14500} \times \frac{45}{1} = \frac{540}{14500}$ ins. $= \frac{3}{80 \cdot 5}$ ins. approximately. In addition to this the elasticity at the strain previously mentioned of the fastenings, the length of which would be approximately 16 ins., and the stretch per inch $\frac{3}{84}$ (by reason of the proportions) of the former quantity, say $\frac{4}{9}$ of $\frac{12}{14500} \times \frac{16}{1} = \frac{1}{170}$ ins. approximately, which with the former quantity would amount to about $\frac{1}{87}$ of an inch for the full length of the piston line, due to a strain upon it of 24 tons. This is instructive, and explains a good many things, especially the reason why lines of parts with short fastenings and "cut-in" sections which are subjected to heavy shocks work loose if not secured by such provisions as split pins, and also the saving effects of good proportions. At 450 revolutions of the example in the diagram the inertia would amount to 4,405 lbs.—something less than 2 tons—and the stretch would be about $\frac{1}{200}$ of an inch for the full line. At 600 revolutions, at which the strain of inertia would be 7,832 lbs. (about $3\frac{1}{2}$ tons), the stretch would be about $\frac{1}{140}$ of an inch.

All these quantities are calculated on the strongest material available and the lightest line of parts compatible with perfect safety, and are put forth simply for example. With heavily designed lines and weaker material, of course different results would accrue. As the modulus of elasticity of wrought iron or mild steel, and that of annealed steel of the quality described for the example, does not greatly differ (it is slightly greater), the elasticity of a piston line constructed of either of these materials would have a similar elastic extension up to the limit of elasticity of the metal; and it would thus appear that as the strength up to the limit of elasticity of the higher quality of material is 50 per cent. above that ordinarily in use, while its actual elasticity is about the same, there is no bar to its use but its cost, which, in case of very important work and for such express purposes as destroyer engines, would be admissible. It is obvious that it is always worth while to make a limit diagram of a piston line, in order to ascertain the exact position of the conditions under which an engine works. It is evident, from the showing of the diagram, that with a 24-in. stroke a speed of about 525 revolutions per minute would be available for such express purposes as torpedo boats or destroyers, with a margin of safety of three times on the half-limit of elasticity of the best quality of steel available for the purpose; and that if the material was sound it would be perfectly safe to run at such speeds, as the margin of safety would still be about 12 times on the actual ultimate strength, or six times considered as a sudden load. At the same time it is equally evident that in such extreme cases there is no room for bad design, for increased weights or small fastenings would very soon destroy the margins indicated.

Inquiring into the value of the elasticity of a piston line, perhaps the possibility, when running full speed, of priming to such an extent as to fill the clearance and

any part of the piston sweep may be dismissed. It is true that it may be filled at the commencement of a run by either or both priming and condensation, but the speed would be slow, increments of water small, stroke by stroke afterwards, and the strength of the piston line up to the half-limit of elasticity would create a pressure of over 600 lbs. on the square inch of piston, which even in the short period of time involved would clear a good deal of water by the valve, gland, rings, and relief arrangement, as also by the lead of the distribution valve. And whereas such a strain as would produce a stretch of $\frac{1}{17}$ in. in the whole line might break a single thread of, say, the piston nut, no injury would occur in a line proportioned in the manner described. In no case could a sudden failure occur without notice, seeing that the elongation produced by a strain equal to the ultimate strength would be 12 per cent. of the whole reduced portion of the line, or about 5 ins. What the effect of a sudden strain in such a connection would be it is difficult to say, or where the fracture might take place, or whether most of the stretch up to the fracture might not come in one place, and so on; but, on the face of the case, it is pretty clear that the likelihood of the piston line giving way, with such disastrous consequences as have sometimes occurred, would be reduced to a minimum. The worst and most destructive accidents have arisen out of the breakage of the "motion" while running at full speed.

Granted the possibility of priming to such an extent as to form a dead-water lock, no possible construction of piston line could prevent disaster to such an engine as described when running at 450 revolutions per minute. The pulsations of such an engine (taken from actual trial), with a steam pressure of 90 lbs. and a $\frac{3}{8}$ths cut-off on a piston 86 sq. ins. area (working non-condensing), were about 5 per cent. The tangential accelerating force, reduced to the path of the crank centre, was about 3,000 lbs., and the time of the acceleration up to normal speed 3 secs. The normal speed of the crank centre being, roughly, 15 ft. per sec., the distance due to fall at that rate would be $3\frac{1}{2}$ ft. The increments of speed due to the pulsations of the piston being 5 per cent. of the normal (450 revolutions), that speed would be reached in $22\frac{1}{2}$ revolutions, and the quantity of work performed in acceleration would be approximately 70,000 ft.-lbs.; and as $3\frac{1}{2}$ ft. would be the distance in which a body falling free would attain a velocity 15 ft. per sec., $\frac{70,000}{31}$ would be the weight of such a body as would in the distance produce accumulated work to the amount of 70,000 ft.-lbs., and would therefore be the amount (20,000 lbs.) of the resistance to acceleration. The ultimate elongation of the piston line of the example, when taking the testing machine results for crucible steel, would be 12 per cent. of the reduced parts, or 12 per cent. of 45 ins. $= 5\frac{2}{5}$ ins. But as a fracture due to a sudden shock would probably occur with a less elongation than that of the testing machine—say, for the sake of argument, $2\frac{1}{2}$ ins., if the 70,000 ft. lbs. of work are to be absorbed in that distance, the required resistance would be $70,000 \times 4{\cdot}8$ ($2\frac{1}{2}$ ins. into 1 ft.) $= 336,000$ lbs. $= 150$ tons. The ultimate strength of the line as shown would be 108 tons, or 54 tons to a sudden load; so that it is evident that any attempt to provide a piston line strong enough to withstand a water lock would be futile, as the force generated would break a piston rod of $2\frac{3}{4}$ ins. diameter in the small part, which, for a $10\frac{1}{2}$-in. cylinder, would be an excessive size. Ordinarily, however, "testing-piece" proportions, such as advocated, would secure an engine from those breakages which arise out of short weak parts, "cut-in" sections, and gradual deterioration of parts subjected to such shocks as are caused by the knocking of the piston in the cylinder end (generally due to neglect of adjustment of the brasses for wear), and which are the chief cause of the breakage of big end bolts and rods. Such a piston line as described would work without taking a permanent set while striking the cylinder end so badly that the engine could not be turned round by hand when not in steam without employing considerable force, so that cylinder-end knock could not be mistaken for water-knock.

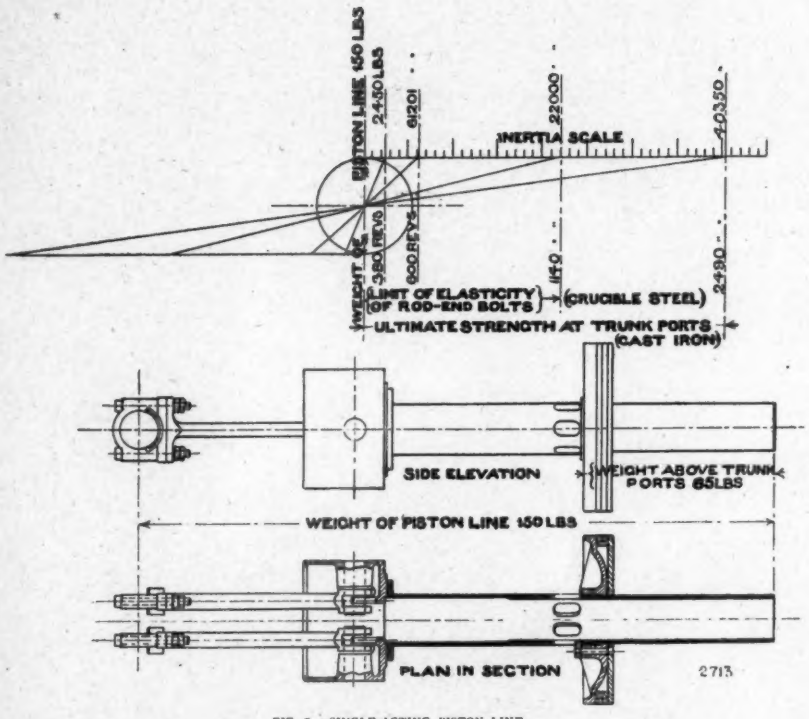


FIG. 3.—SINGLE-ACTING PISTON LINE.

It goes without saying, that the strains in the different fastenings in a piston line are according to the weights of which the inertia takes effect; starting at the big end bolts with the full strain of the line, becoming less at the gudgeon pin and least at the piston nut or cotter, where only the piston inertia has to be reckoned for; but, as failures are largely the result of accidental occurrences, say of water lock, seizure in the cylinder, rings or broken portions getting into the ports, nuts or screws coming loose, and so forth, if the sections were not maintained throughout, and any such accident took place, the benefit of the stretch of the line would be lost, as it would break in the weakest point. It is therefore the safest plan to make the whole of the sections of uniform strength.

As a comparison to the conclusions of figures on Fig. 2, those on Fig. 1 have been made to illustrate the effects of inertia in single-acting engines. The drawing of a single-acting piston trunk and connecting rods has been taken from the practice of a standard make. The weight taken is closely approximating to 150 lbs., which is probably rather less than the actual weight. There are four $\frac{5}{8}$-in. big end bolts, which in the bottom of the thread will have an area of $\cdot 204 \times 4 = \cdot 816$ ins., which, on the same basis as the former example of 12 tons per sq. in. of metal in the big end bolts (crucible steel), would give $\cdot 816$ of 12 tons $= 9 \cdot 792$ tons available for the limit of inertia and speed, calculated on the limit of elasticity of the metal for sudden load (half testing-machine strength). This is 21,952 lbs., say 22,000 lbs., and is equivalent to the inertia of a piston line weighing 150 lbs., with an 8-in. stroke

at 1,150 revolutions per minute. This relates to the big end bolts alone. There would be a margin of three times at 665 revolutions. The ports in the trunk under the piston leave about 3 ins. of metal for tension in the up-stroke. If the ultimate tensile strength of this be taken at 12 tons, and at 6 tons for sudden load, per square inch, there would be 18 tons available in tension under the piston. As the piston and portion of the trunk above it weigh about 65 lbs., inertia would be equal to the available ultimate strength of the trunk at 2,490 revolutions per minute; this gives about four times as much strength in the trunk as in the big end bolts. The piston line here taken, for example, belongs to a 6-in. stroke, but has been converted for the sake of example to an 8-in. by lengthening the trunks and connecting rods. Reckoned for a 6-in. stroke, the margin would, of course, be greater, and would correspond to a speed of 1,330 revolutions for the big end bolts and for the trunk under the piston 2,700 revolutions per minute.

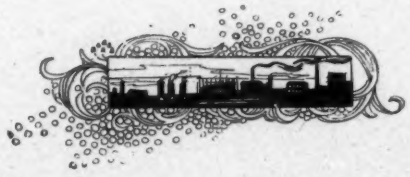
This piston line is probably as light as it is practically possible to make it. It is not liable to accidental fracture on the down-stroke, and on the up-stroke has the advantage of the great strength of cast-iron in compression. It is also a very cheap construction, but only does half the work of a double-acting engine; a piston line for which latter could consequently cost double, added to the price of an extra cylinder and valve motion and part of the frame, and still be the same price, work for work performed. In compounding, however, the single-acting engine, especially of the type illustrated, increases its efficiency with very little extra cost.

The total amount of piston-line inertia in a single-acting engine to Fig. 3 would be due to 300 lbs. against 192 lbs. in the double-acting case; but the inertia effects would be divided into two lines.

In regard to the strength of the piston line and possible rates of revolution in both double- and single-acting engines, it is sufficiently evident that very much more than is common practice can be accomplished by designs which are made with a proper appreciation of the forces to be provided for; and prospective users of these classes of engine have no grounds for uneasiness or uncertainty as to the risks which they are likely to run in their employment. Such engines are, in fact, both actually and relatively much stronger and more reliable in the matter of safety than any other class, and the possibilities of extensive damage losses are very much reduced from those which hold with long-stroke engines.

H. H. Dales

(To be continued.)



The Valtellina Electric Railway.

By OUR SPECIAL COMMISSIONER.

THIS is an undertaking which is especially interesting to both electrical and railway engineers. It is the longest railway up to the present, which has been entirely equipped for running by means of electric motors, and its length brings within practicable limits many of our railways leading out of London. The total length of the line is 66 miles odd, while the length of the line from London to Brighton is only 51 miles, and that from London to Portsmouth only 85 miles. The power for the line is furnished entirely by falling water, taken from the River Adda, which runs near one portion of the line, a convenient supply having been arranged near the middle of the service. The line is departing from the time-honoured pressure of 500 volts, and from other methods which have been practically imposed upon the electrical world by the American engineers, who were the pioneers in electric traction. The engineers of the Valtellina railway have made the bold departure of using a 3,000 volt service on the trolley wires, and transforming this pressure down to 300 volts in the motor itself.

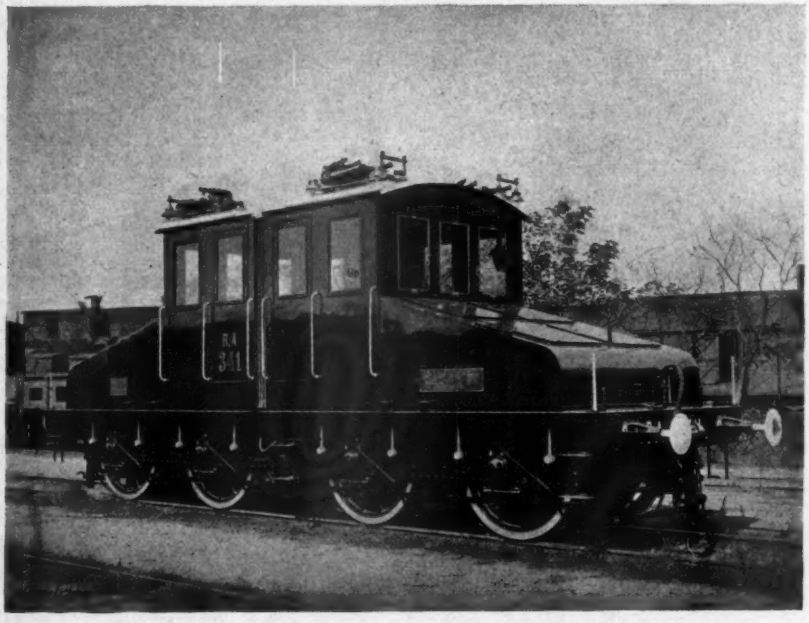
Lake Como, as will be seen from the map, is in the form of a hay-fork, the two prongs running southwards, and the line runs from Lecco, on the shores of the eastern arm of the lake, to Colico, near the head of the lake, following the course of the eastern arm for that section. At Colico it divides, one branch going eastwards to Sondrio, and the other section going northwards to Chiavenna, where it is intended to connect with the Swiss system of railways leading to St. Moritz, and other places. The line is a portion of the Italian Railway serving that district of Northern Italy, and is intended as a pioneer installation, the remainder of the line to follow. Besides the three termini, and the junction at Colico, there are sub-stations for power distribution at Abbadia, Lierna, Bellano, and Dorio on the Lecco Colico section, and at Ardenno, Castione, and Cosia Fraona, on the Colico-Sondrio section. There is no station between Colico and Chiavenna.

The power station is situated at Morbegno, which is about 9½ miles from Colico, and 15½ from Sondrio, a canal being led from the neighbourhood of Desco, near the Ardenno sub-station, to Morbegno. The canal is between two and three miles long, and the fall at Morbegno is 98 ft., the quantity of water available being stated to be 35 cub. metres per second, which would give a gross power in the water of nearly 13,000 h.p. There are four turbines in the power station, each capable of exerting 2,000 h.p. when supplied with water at the pressure described, directly connected to four Schuckert three-phase generators, which furnish current at 20,000 volts and 15 cycles. The currents are taken from the power-house by three hard-drawn copper wires, each ·32 ins. in section, supported on porcelain insulators of the quintuple petticoat pattern, to the 10 sub-stations mentioned above, which are at distances of about 6·2 miles apart along

MAP SHOWING THE ROUTE OF THE VALTELLINA ELECTRIC RAILWAY.

the line. At the sub-stations, the currents are transformed down, by stationary transformers, to 3,000 volts, at which pressure the different sections of the line are fed. The motors on the trains are supplied from two overhead trolley wires, each 0·32 ins. in diameter, the rails of the track forming the third wire necessary for the three-phase service. The trolley wires are suspended from steel wires, which are supported by poles on either side set up for the purpose, at a pressure of 40,000 volts. The stationary transformers in the sub-stations are of a capacity of 450 kilo-watts each.

The current is collected from the trolley wires by two aluminium rollers, carefully insulated from each other, both for the ordinary working pressure, and against sparkling under induced pressures. But the current does not pass to the motors from the axles of the aluminium rollers.



VALTELLINA ELECTRIC RAILWAY: FREIGHT LOCOMOTIVE.

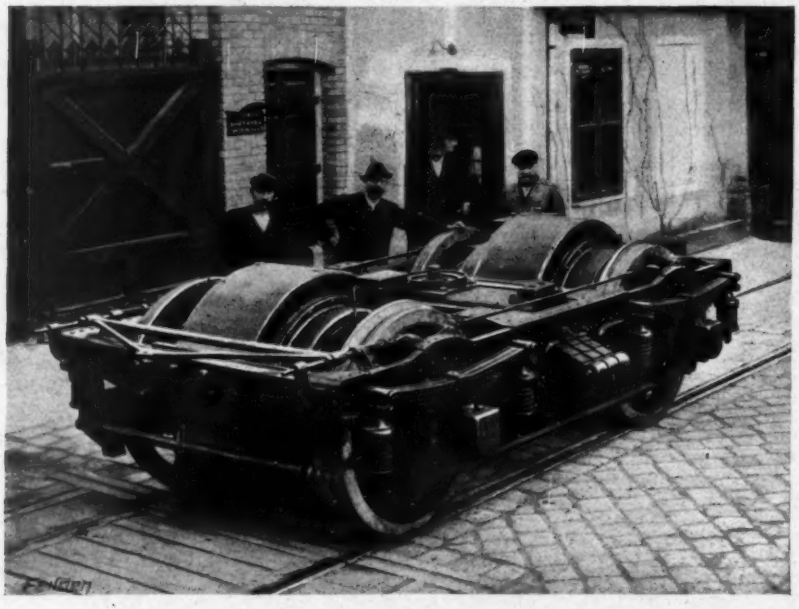
of the track, the poles being spread by cross-beams, as shown in the illustrations; the main supply wires, in which the 20,000 volts pressure is present, being also supported by the same poles which support the trolley wires. In the tunnels, of which there are no less than 32, the insulators are carried by wrought-iron suspenders, firmly secured in the masonry of the tunnel. The insulators themselves are tested in a special laboratory

Collecting brushes running on graphite collars collect the current from the rollers, and pass it on to the stator windings of the motors, by heavily insulated cables, vulcanised rubber covered, enclosed in metal tubes, the tubes being well connected to earth. The collecting rollers are 16 ins. long, and 3¼ ins. in diameter, and the two rollers are separated by 5 ins. of hard wood which has been saturated with paraffin, under pressure. The rollers also

revolve in steel ball bearings, but, as mentioned above, no current passes through the axle or its supports.

The arrangement for producing good contact is also novel. The two rollers are mounted on a cast-iron framework, hinged to the top of the car, the frame being connected mechanically to the piston of a compressed air cylinder, so that the trolley is raised and lowered entirely by air pressure, and one feature that is claimed for the system, in the matter of safety, is the fact that no train can take current from the overhead wires unless the compressed air apparatus, which also works the brakes, is in proper working order. As will be seen below, compressed air is used in another novel and interesting manner, as well as for providing the necessary contact pressure. A small three-phase motor is provided for working the air-compressing apparatus, taking its current at 100 volts from a transformer, carried on the locomotive, or the motor-carriage.

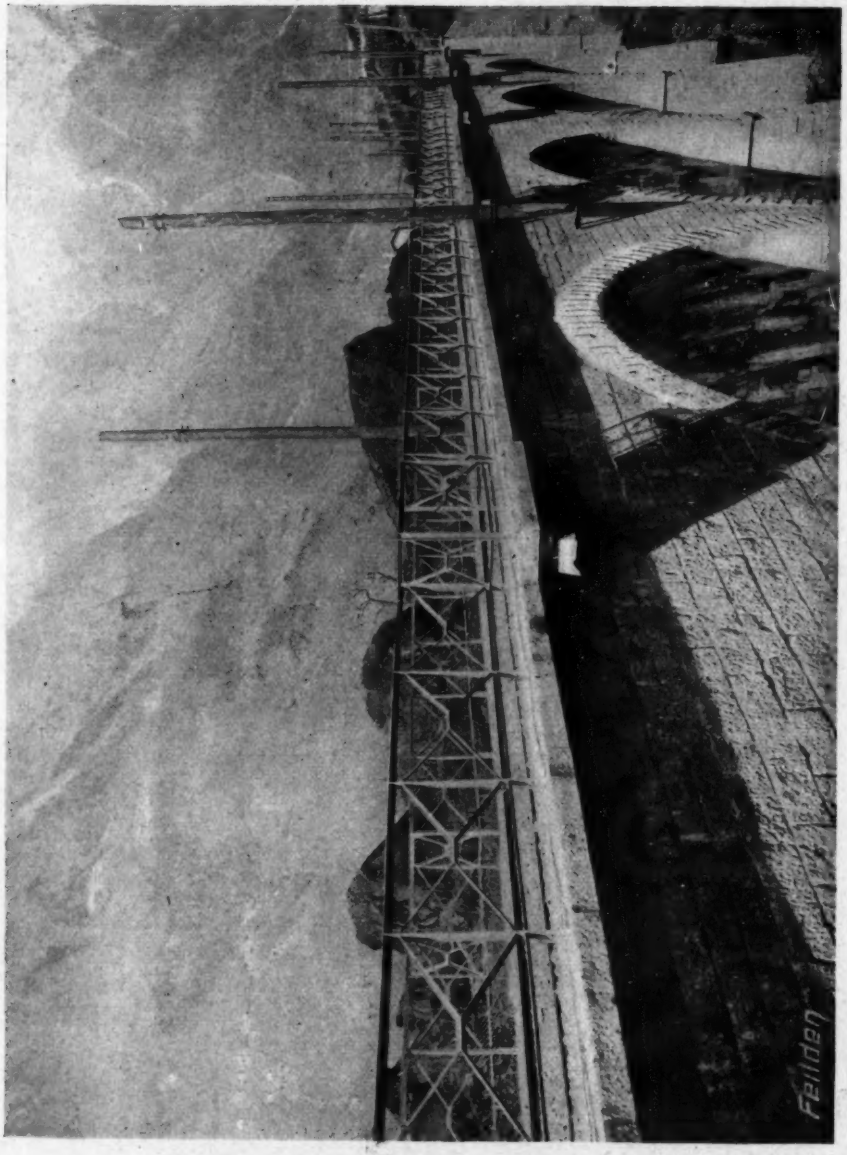
The arrangements for passenger traffic and for goods traffic are different. Goods traffic will be hauled by locomotives of the form shown in the illustration, passenger traffic will be dealt with by motor-carriages, something on the lines of the Sprague independent unit system, but the motor-car itself will act as the locomotive, pulling four trailers after it, the trailers being the ordinary Italian railway carriages. Plan and section of the motor-car are shown. But the locomotives and the motor-cars are fitted alike in the matter of driving arrangements. Each is supported on two bogie trucks of the pattern shown in the illustration. Each bogie truck carries two motors, one on each axle, so that each locomotive and each motor-car has four motors, each motor being rated at 150 h.p. But two of the motors on the motor-cars are only used during



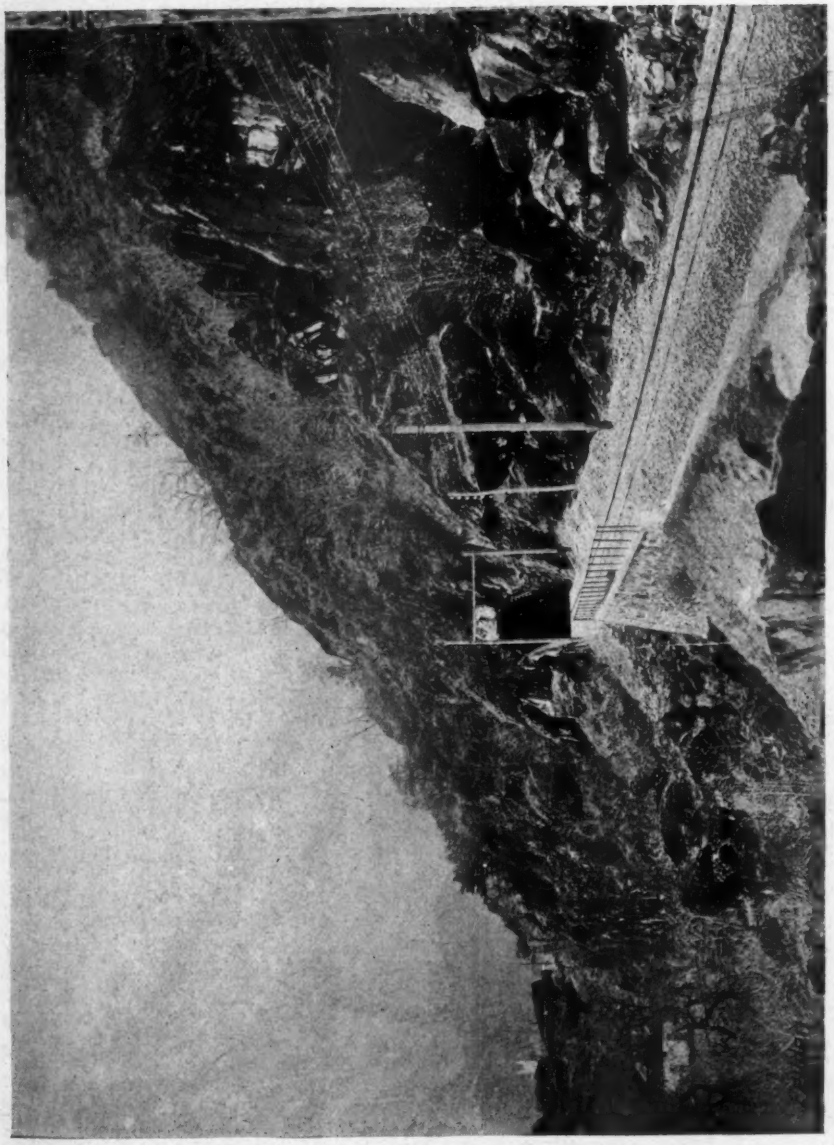
VALTELLINA ELECTRIC RAILWAY: BOGIE TRUCK FOR MOTOR CAR.

VALTELLINA ELECTRIC RAILWAY: PART OF THE LINE ON THE MOUNTAIN SIDE.

VALTELLINA ELECTRIC RAILWAY: A STATION ON THE LINE.

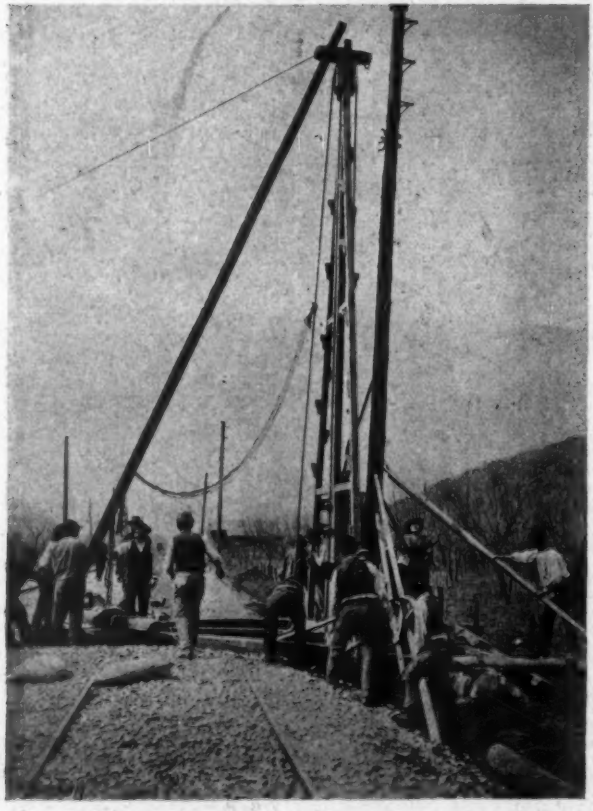


VALTELLINA ELECTRIC RAILWAY: THE CHIAVENNA BRIDGE.



VALTELLINA ELECTRIC RAILWAY: ENTRANCE TO A TUNNEL.

starting, and take the place of a large portion of the usual starting resistance, Messrs. Ganz claiming that they obtain quicker acceleration and economy in working by using the second motor on each truck, in the manner to be described,

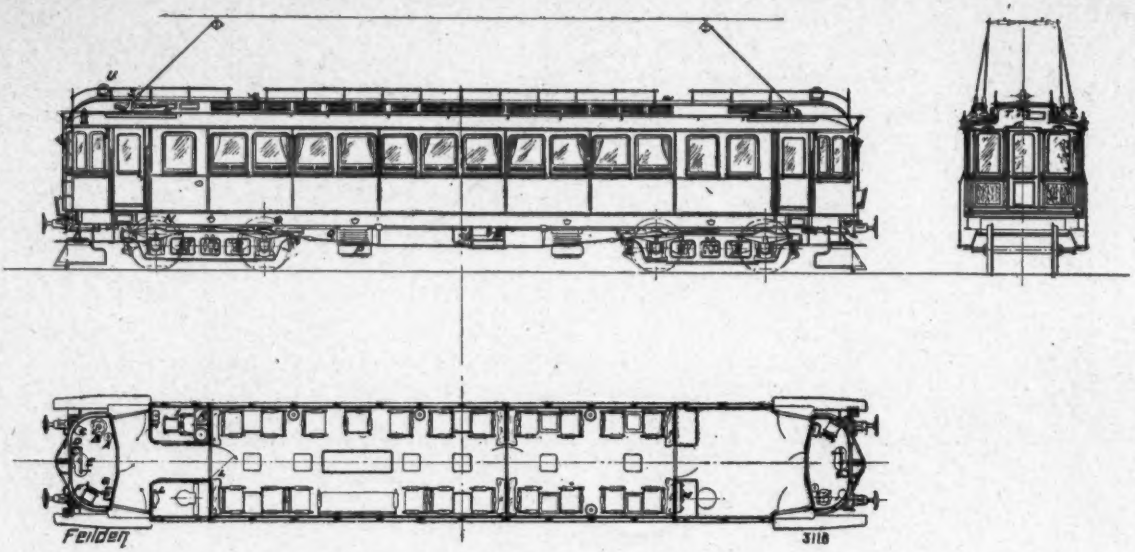


VALTELLINA ELECTRIC RAILWAY: FIXING POLES FOR LINE AND TROLLEY WIRES.

than is obtained by using resistances in the usual way. They claim, and it seems with justice, that it must be more economical to obtain an additional starting torque from the current that would otherwise be converted into heat, and thereby wasted for the purpose of starting the train.

It should be noted that, on the Metropolitan Railway, Messrs. Ganz propose to use two motor-cars with each train, one at each end of the train, the two working together something after the manner that Mr. Sprague works his independent cars.

The motors are all of the three-phase induction type, the armature being of the squirrel-cage pattern, but all conductors being fully enclosed within tunnels in the iron, and this construction applies also to the high-tension portion, in which the 3,000-volt currents are passing. The armatures of the motors are mounted directly on the wheel axles of the bogie-trucks, as in the motors of the Central London Railway, and other forms. When the train is running at its normal speed, only two motors on each car are in use, these two being rated together at 300 h.p. At starting, however, the second motor is brought into service in a manner that has not, so far, been applied to railway work or to induction motors, though the system is not unknown to electrical engineers. The supply service at 3,000 volts, delivered to the stator of the driving motor, generates (by means of its revolving magnetic field) currents in the armature of its own motor at 300 volts pressure, and when starting, this 300-volt current is delivered to the stator windings—the field windings of the second motor—these windings being arranged to receive the low-pressure three-phase currents generated in the armature or rotor of the



VALTELLINA ELECTRIC RAILWAY: 4-AXLED ELECTRIC CAR.

A. Hand-pump or trolley.
B. Hand-brake.
C. Compressor-switch.
D. Westinghouse brake-valve.
E. Controller.
F. Primary cut-out.
G. Distributing-box.
H. Switch-governor.
I. Compressor with motor.
K. Chief air-tank
L. Heating-box.
M. Switch-board.
N. Primary (main) motor.
O. Secondary (auxiliary) motor.
P. Liquid rheostat.
Q. Transformer.
R. Accumulator.
S. Trolley.
T. Incand. lamp with fan.
U. Torpedo ventilator.

10 seats in smoking room.
20 seats in the other compartment.
Weight of the whole electrical equipment 21 tons.
Weight of the car ... ... 32 ,,

Total ... 53 ,,

Brake-system—Hand and Westinghouse brake.
Lighting with incandescent lamps.
Electric heating.

driving or primary motor. The presence of the revolving field in the stator of the second motor creates motion of revolution in the armature, the rotor of the second motor, so that, at starting, instead of one motor only being in service, two motors, acting on two axles, are performing work in getting up the speed of the train. The speed at starting is necessarily lower than the normal running speed, and when the running speed has reached half the normal speed, the second motors are cut out, and the currents from the armatures of the primary motors are diverted to resistances provided for the purpose, which are gradually cut out in the usual way as the train gets up speed. The current generated in the rotors of the second motors are passed through resistances also provided for the purpose. The resistances themselves present features of considerable novelty. They are of the fluid type, but of special design, and with the very novel feature that the fluid moves, and not, as in other cases, either the plates or the containing vessel. The resistances are contained in an iron box having three separate portions. In each division, depending from the top of the box is an iron cylinder, and inside each cylinder are two sets of iron plates, which are of different lengths, and rounded at their ends. The three sets of plates in the three cylinders are for the currents of the three phases, and it will be seen that if liquid is caused to mount up the inside of the cylinders, meeting plates of unequal length in its passage, the resistance will be lowered as the liquid rises, just as if plates had been lowered gradually into liquid, the lowering of the resistance following a special law depending on the lengths of the plates and other factors. The iron box contains a solution of sodium carbonate, which, when the resistance is not in use, remains out of contact with the plates. Compressed air is, however, admitted to the upper part of the box, when it is required to make use of the resistance, and forces the liquid up into the cylinders, releasing the air, allowing the liquid to fall down again, and putting the resistance out of circuit.

The arrangement of the two sets of motors "in cascade," as it is sometimes termed, is also made use of for braking purposes, the two motors acting as dynamos in the well-known manner. It is stated that the use of the resistance described above enables the torque delivered by the motors to be maintained constant during the time of acceleration. The height to which the solution rises in the resistance boxes does not exceed 12 ins.

The passenger trains are designed to run at 39 miles an hour on all gradients under 10 per cent.; above that, the speed is halved, the cascade arrangement of motors being again brought into use.

For goods traffic, the running speed will be 20 miles an hour, all four motors on the locomotives, or 600 h.p., being employed on all gradients up to 10 per cent. The freight locomotives are designed to draw loads of 250 tons at that speed. The motor-carriages are designed for carrying 60 passengers, and 2 tons of luggage, and weigh 54 tons each unloaded. They are 62 ft. long between buffers. The first installation consists of 5 first-class motor-cars, 5 cars for local trains, and 2 freight locomotives. The power at present provided for is intended to deal with 750 tons of load at one time, which may consist of five passenger trains, or two passenger trains and two freight trains.

There are gradients on the line as steep as 22 per cent., and curves with radii as low as 1,000.

The trolley wires are carried at a height of 19 ft. 8 ins. above the rails, except in tunnels, where it is reduced to 14 ft. 9 ins.

The trolley wires are doubly insulated. They are suspended from specially strongly-constructed insulators, consisting of iron petticoats, with Amboin insulation, and the insulators themselves are suspended from steel wires, which are insulated at their supports, the poles on the open line, and the masonry in the tunnels. No joints are soldered; all are made under pressure, the ends of the conductors to be connected together being placed in a small tube, and the whole squeezed up together by hydraulic or other suitable pressure. The turbines are governed by a novel arrangement. A centri-

fugal ball-governor of the usual type opens the valve connecting a reservoir of oil under pressure with two cylinders whose pistons are mechanically connected to the gates, and which are worked by the oil under pressure. The pressure of the oil in the reservoir is maintained by means of a pump connected to the turbines. The gates are of the cylinder type.

The alternators are of the revolving field type, the revolving portion being directly connected to the turbine shaft, and the exciter carried on the main shaft, as is usual in these cases.

The shafts of the motors are built hollow, and lined with brass, and are connected mechanically with the axles they are driving by means of flexible couplings.

The lines are well provided with protection against lightning. Groups of lightning arresters of the well-known horn type are provided at the power house, all of them being fixed outside the building. At the sub-stations, lightning arresters of similar type are provided, but they are fixed inside the buildings. All the locomotives and the motor cars are also provided with similar apparatus. The horn type of lightning arrester, it will be remembered, is that in which the lightning discharge is made to pass between two horn-like projections, one of which is connected to earth, the spark which passes across the gap being blown out by the operation of the magnetic field produced by the electro-magnet placed there for the purpose.

The trolley wires are carefully protected against accident. At crossings, guard wires, fully earthed, are fixed. At points where the 20,000-volt service has to cross the 3,000-volt trolley service, the trolley wires are completely cut out for 10 ft., their place being taken by paraffined sticks, the paraffin having been forced into the pores of the wood under pressure. The train service is not interrupted by this arrangement, as each locomotive and each motor-car carries two sets of trolleys, one at each end of the car, to deliver the current to the motors on the two bogies, and the distance between the two trolleys is greater than the length of the paraffined sticks.

The now usual method of blocking trains on electric railways is also made use of on the Valtellina railway. The railway block signals are arranged to control the supply of current to the trolley wires on the different sections of the line. If a train receives a blocking signal, it also has its current cut off, so it cannot proceed. Also, it is arranged that each train, as it enters a particular section of the line, cuts off the current from the train following it on that section, and reopens the supply as it leaves that section. Where a train is coming up at full speed, and it is necessary to order it to stop, owing to the sudden occurrence of something in front, the signalman not only makes the signal to stop, but he also cuts off the current, and applies the full braking power available to the advancing train.

It will be understood that the power stations and the sub-stations are in full telegraphic and telephonic communication with each other. When a train is standing in the station also, it is arranged that the trolley wires with which it is in connection are deprived of current, until it receives the order to start. At all stations also, there are two complete sets of trolley wires, four in all, to facilitate shunting and similar operations. A provision is also made, in case of the turbines running away. A centrifugal governor, working on the common shaft, inserts a resistance in the circuit of the field coils, if the speed passes a certain pre-arranged limit.

It will be seen from the above that the whole of the details have been very carefully thought out, and that full advantage has been taken of all recent discoveries, while no unnecessary chances are being taken. The work is necessarily new in many respects, and engineers will watch its working with great interest, as it can hardly be doubted that the day is not far distant when all railways will be worked by electric motors, and when troubles which vex the soul of the locomotive engineer will trouble him no more.

S. F. W.

Some Arctic Industries.

By E. WARD LOWRY, F.R.G.S.

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Few Russian peasants work continuously at any one trade, but most occupy the time between seed time and harvest, fishing and fowling, with some handicraft, in which their wives and daughters can take a part. All Russian industries are characterised by their intimate connection with rural economy, by the attachment of the peasant workers to the land; in contradistinction to those of Western Europe, which are marked by the complete separation between the manufacturing and the agricultural labourer. The Russian factory-hand seldom abandons his village allotment entirely when he gets work in town, but generally returns to it, and to his family, yearly, at some season—such as harvest—when agricultural labour is at a premium. By thus exchanging the factory for the field, and keeping up his connection with both, the urban worker secures a good change of air and employment each year. Besides this, he is rendered more independent of the manufacturer, and is not left to starve if work falls through; on the other hand, this does not tend to improve his town work, and encourages frequent changing from one kind of employment to another; for if, on his return from the land, he does not find his old situation open, he very soon drifts into another. In this way many have held that the system is to blame for the rough state of finish shown by many of the products of Russian factories. To this fact—due in its turn to the communal system—and to the long idle days of winter, may also be attributed the small headway made in Russia by the manufacturing centres; while almost every village has developed some domestic industry, which, conjointly with husbandry, and, as a rule, fishing, affords a living to the peasantry. Statisticians, working however with but uncertain data, have even asserted that the output of the village workers is far greater than that of the factories. For example, in the leather trade, according to recent statistics, the production of the manufactories is estimated at 37 to 42 million roubles, while that of the village workers stands at 58 million.

These village, or "Koostar," industries vary greatly in different parts of the empire, and embrace some fifty different trades: cotton, leather, hardware, cutlery, eikons—the sacred pictures which stand opposite the door of every Russian room, be it grand saloon or ticket office, theatre or workshop, and to which all must bow on entering—baskets, and a host of other articles in every-day use; all have their group of villages, where they are made in large quantities, being passed from village to village through the different stages of their manufacture. Finished goods are seldom turned out of one hamlet, but are—in such a case as that of birchwood spoons (Fig. 6) made in the Government of Novgorod — cut in one, shaped in another, finished in the next, and painted in a fourth, men, women, and children contributing to the production in each successive stage. The value of these spoons never exceeds 5 roubles per 1,000; yet no single family, or even village, is able to produce the finished article unassisted. The making of cart-wheels, the value of which is about 2 roubles per pair, is another example of this: the naves are made of birch or alder, the spokes of mountain ash, the tires of winter-felled poplar, each in a separate village; in yet another they are put together and coated with hot tar; and so the finished article comes at last upon the market. The work of these villagers is not as a rule characterised by any great fineness or elegance, which is not to be wondered at when the lack of technical education, of any but the simplest and most antiquated

tools, and the difficulties of finding a market at fair prices, are taken into account. In a village producing nothing but baskets, baskets are necessarily of little value, and must be carried many a long verst before a remunerative market can be reached, and herein is felt a want which presses hard on all Russian industry, the lack of sufficient railway communication, and the expense and delays of such as now exists.

The manufacture of Archangel tar and pitch is an auxiliary occupation, which does a good deal to eke out a living for the northern mujik. Two descriptions of wood tar exist: that obtained from hard woods, as a residual product in the making of charcoal for gunpowder, and that empyreumatic variety obtained by roasting coniferous timbers, which is imported to England from Stockholm and Archangel. The manufacture of the Archangel product is primitive in the extreme, and is undertaken by artels—or profit sharing associations—of peasants, who, with their wives and families, fill up with tar burning such time as cannot be more profitably employed. Pine, fir, larch and birch, are the trees most used; but almost any wood on which the peasant can lay his hands is burnt. Windfallen rotten trees, and stumps which have remained for years in the ground, yield the best results. The peasants kill trees purposely, by tearing off strips of bark some five feet in length from one quarter of the circumference, and during the three successive years from the other three quarters, thus causing the tree to dry up, and all resinous matter to exude on the sides stripped. This is scraped off, and used for making a pure and high quality of pitch. A far higher percentage of tar can be obtained from bark than from whole timber. Tar is an oily liquid, consisting of a solution of pitch in turpentine oil and creosote, from which pitch can be separated by redistillation. Another method of obtaining pure pitch, such as is used for smearing the bottoms of ships, is by stripping off the thin upper bark from birch trees and distilling it. This pitch differs from black tar, not only in being free from turpentine and creosote, but in containing a higher percentage of paraffin; it is, however, expensive, and, therefore, can only be used for the best work, whereas for dressing leather and other purposes a cheaper substitute, called "half pitch," which is obtained by the distillation of tar mixed with some birch or ash bark, is employed.

When all the available wood has been

FIG. 1.—NORTHERN DRAWN THREAD WORK.
FIG. 2.—COLLARETTE AND FRONT OF HOLMAGOR LACE.

FIG. 3.—ARCHANGEL LACE.
FIG. 4.—TOWEL ENDS.
FIG. 5.—LINEN PEASANT DRESS.

collected, and the peasants have no more profitable work on hand, they commence burning. A ditch is dug, or a floor of clay made, and so sloped towards the centre that all liquid products of distillation will run towards it. This apparatus is usually constructed on the side of a hill, and the drain connected with barrels, into which the tar runs by the force of gravity. On this foundation of clay the wood is closely piled up so as to form a conical heap, surrounding a central flue. This heap is then covered with clay or earth, mixed with seasand, so that a fireproof jacket some 1½ ft. in thickness is formed. The pile is then lighted at the bottom, where a little pitch has been spread on the wood, and when well alight throughout the holes are closed, one at a time. The wood is thus, to use a chemical term, submitted to destructive distillation, or slowly roasted with but a very limited supply of air; for were oxygen admitted freely, the timber would of course be merely burnt to ashes, whereas by this process—which is a crude form of that through which coal passes in the manufacture of gas—the elements of which wood is composed are simply rearranged, one of the many products of this rearrangement being tar. Tar-burning is a strange sight when suddenly come upon at night; the blue flame which shoots up from the top of the pile shedding a weird light on the trees around. The process is very long, primitive, and wasteful, only about 10 per cent. of tar being obtained from wood and 15 per cent. from roots; while such valuable chemical products as methyl-alcohol, pyroligneous acid, and wood naphtha are lost.

In the Swedish forests this process is being superseded by distillation of wood in cast-iron retorts, whereby a yield of 14 per cent. is obtained from trunks and branches, and up to 20 per cent. from roots; while the condensed products separate into two layers, the upper a mixture of pyroligneous acid, acetone, methyl acetate and other bodies; the lower being tar. From the upper layer, on redistillation with chalk, three products, wood naphtha, calcium acetate, and methyl-alcohol are obtained separately; the former finds a ready sale for varnish making, while methyl-alcohol forms 10 per cent. of methylated spirit, and for that purpose is marketable at good prices. Yet in Arctic Russia thousands of pounds of these riches of nature are lost, owing to want of proper and by no means expensive retorts, and to lack of technical education. What dividends could gas companies pay were they to neglect the by-products when distilling coal? Coal tar, carbolic acid, ammonium carbonate, and sulphide, as well as coke, are all side issues in the

gas-making industry, and an almost equal proportion should be derived from tar-making. Some day, perhaps, an enlightened class of mujiks will wake up to this fact, and make fuller use of nature's priceless gift, the forest. But ere this can be brought about, years must pass, schools must be established, cheaper freights by road and rail, and better means of export found. There is coal in Archangel, just as there is in the Caucasus, in Turkestan, the Kirghiz Steppes, Poland, the island of Sakhalin, and in Siberia generally: who can say if in years to come, when our coalfields have become smaller in proportion as our wants become greater, we may fall back on Russia, through the water-gates of her new ice-free harbour on the Murman coast, thus proving the prophecy of Peter the Great, who, when shown a coal fire, said: "This mineral will be exceedingly useful, if not to us at least to our descendants."

Another peasant occupation in the North-Eastern Provinces is the growing of flax, and its manufacture into linen, rope, and linseed. Flax spinning was first introduced into Russia by the English, who, in the sixteenth century, started a factory at Holmagor, the former capital of the enormous sub-Arctic province of Archangel, situated on the Dwina, some 90 versts above Archangel. Much Russian flax finds its way to England; while of the remainder the peasants make their clothes, fishing nets, and cords. Whether intended for home use or for the market, the whole of the many processes to which flax is submitted take place in the homes of the growers, or of those who buy from them, seldom in any large factory, although of late years several such have come into existence. Thus—to use the old Scotch terms—flax is sowen, weeded, plucked, steeped, retted, scutched, by man and wife; cleaned, spun into yarn, woven, bleached, finished, and often embroidered, by wife and daughters. The crop requires a deal of labour to raise and bring to market; but is fairly remunerative to the grower. The plants must be well and carefully weeded when young, plucked—not cut—by hand when fully grown, a very tiring occupation, and one which must be done in the nick of time. After they have been plucked, and left in the sun to dry for a time, comes the process known in Scotland as "rippling," which is done by beating the bundles against the foot-long teeth of an immense comb—until all the seeds are shaken out, and so the two primary commercial products of the flax plant—linseed and flax—are separated. After rippling, the flax is steeped in water under stones, so that fermentation is set up, and the fibres loosened. Last of the field processes is "scutching," by which the plant is freed from woody fibres by beating, which also renders the remaining fibres soft and pliable. Now the flax has reached its marketable state, and the greater part is simply packed in bales, and exported.

Just as the methods used for extracting tar might wisely be superseded, so in part might that in use with flax be improved with gain in regard to work expended and amount produced. Let us follow, in imagination, some of the flax which has not been exported to lands where it is made up by modern machinery, but is to be manipulated by village workers, who receive the raw material in the same state as do our manufacturers. Spinning is left entirely to women, whose tools—distaff and spindle—although antiquated, are good friends to her, for with them she makes the first step towards clothing herself and family. The distaff is a two-foot rod of birch-wood, on to one end of which the flax is roughly twisted, while held in a convenient position, on the spinster's left by placing the other end in a hole made in the bench. The spindle is a thinner rod some 10 in. in length, one end of which is weighted, while the other is notched for holding the thread as it is made. The spinster begins operations by taking a pinch of the flax fibres from her distaff, she twists them between her fingers into a thread, and fixes one end into the notch on the spindle, holding the other in her left hand. Then she spins the spindle by rotating it between the right hand and thigh, much as our harness-makers twist up a "wax-end," but in such a way that it is thrown out into the air in front of her, where, held by the

thread, it revolves rapidly, imparting a twist to the flax fibres, and so forming a length of thread. The weight at the lower end, by adding to the momentum, keeps up a twisting motion, and also maintains an even pull on the thread, preventing it from tangling or twisting unevenly. This length is then wound round the spindle, and the thread caught in the notch at the point to which it is sufficiently twisted. A few more fibres are taken with the left hand from the distaff and added to the thread, the quick rolling motion of the spindle between the right hand and right leg again supplies the motive-power; once more the fully-twisted portion is wound round the body of the spindle, caught in the notch, and the process repeated *ad nauseam*, until the spindle is full. In this way, a yarn of great evenness and strength is made, and from it the well-known Russian crash is woven. The North of Russia has not yet arrived at the stage of spinning-wheels, far less at that of the double spindle-wheel, still to be seen in our old curiosity shops.

The subsequent weaving is almost as simple and rudimentary as the spinning; parallel threads of yarn are stretched, by means of weights in a frame, to form the *warp*, and the *weft* is interlaced with the warp, forming with the shuttle a woven *web* of great strength. Many peasants can produce most beautiful fabrics, while every woman is able to make strong, serviceable linen. As a rule, the narrower and coarser cloths are made by women, the finer and wider by men. Some villages have special buildings, called "svietelky," for weaving, where ten to twenty peasants work together; they then form an artel, and buy flax and sell linen in common, sometimes employing a pedlar to vend it in far-away districts. Linen is often embroidered with red and blue threads in quaint designs. Only a few patterns are in existence, and originality is conspicuous by its absence. By whom these stock designs were invented no one seems able to say; probably they were brought from Moscovite civilisation by the wives of Old Believers, when fleeing from persecution to the forest. Northern linen is not very white, as it is only bleached in a lye of ashes, with no chlorine, but this fault is easily remedied by having the work well "done up" at a laundry.

Lace is made, by hand, in very fine and beautiful designs, in both linen (Fig. 3) and silk yarn, many of which show a marked likeness to old Maltese. Lace-work is chiefly carried on by the unmarried girls, and often by children of eight or ten; for the outfit required is only small and costs only about 50k. Lace is very cheap and little thought of, none is exported, and even the best workers find it hard to earn more than 20k. (6*d*.) a day with their pillows. Illustration No. 2 on page 39, shows a collarette and front of yellow silk, the handiwork of a peasant girl near Holmagor. In an Archangel shop the writer once asked to see some specimens of lace. Cigarettes having been lighted, in accordance with custom, the proprietor produced lace which he described as one of the most beautiful of the world's productions, but which was in reality the commonest output of French machines, which could be obtained in London for $3\frac{3}{4}d$. a yard; but the Archangel price of which was 1 rouble per arshine (2 ft. 4in.), or 2*s*. 8*d*. per yard: a high tariff and an expensive journey account for much in Russia, but hardly for this increase. The vendor was greatly surprised on being told its English value, and stated that every lady in the province bought it, and only peasants used the native product. This was perfectly true, and was borne out by his retailing laces 3 ins. wides, the product of infinite toil on the pillow, for 60k. to 70k. the arshine (1*s*. 3*d*. to 1*s*. 6*d*. per 2ft. 4 ins). Some of these specimens are shown in Fig. 3. The "Polotensa," or national towel, is rather curious to English eyes; it consists of a strip of rough home-made linen, some 5 ft. in length, and $1\frac{1}{2}$ ft. in breath, which is gradually used from end to end, so that with care it may be made to last clean for a long time. The ends afford an excellent opportunity for displaying the skill of the maker, and even the poorest housewives make some attempt at ornamentation. Very quaint are the designs (Fig. 4) worked on these towel-ends in

FIG. 6.—WOODEN SPOON.
FIG. 7 & 8.—BIRCH BARK MILK PAIL (FRONT AND BACK VIEWS).

drawn thread work. Sometimes these figures are not only formed by drawing the threads, but are also outlined in blue or red linen thread. The fronts of the men's summer shirts are an opportunity, seldom neglected, for the display of skill in this kind of work.

The other commercial product of the flax plant is linseed, and the oil expressed from it. The seeds produced in Northern Europe are for some reason very small, but of fine quality, giving a high percentage of oil, and so fetching a good price in the markets of the world. Sometimes they are used for food in Russia, being mixed with corn to eke out a scanty supply: the oil is the popular remedy for sore throat. Tow, the outer rind of the flax stalk, is of little value, but is used for making bags, rough cords, and lamp-wicks.

The carrying of goods by water during summer and by road, or apology for it, during the months of hard frost, with the necessary building of sledges and boats, affords remunerative employment to many. Schooners and other craft are built on many northern rivers during the winter and in summer those who have built them sail them. Working generally in an artel, or profit-sharing association, they trade with Norway or Novaia Zemlia, or fish in the gulfs and bays of the White Sea. That the builders should also be the navigators is not so extraordinary as might at first appear, for every peasant is a born carpenter, whatever trade he may afterwards adopt; every boy learns the use of the axe in chopping firewood; every man builds his own sheds and homestead. Like the sledges and houses, the boats are built almost entirely of wood, with the two invaluable tools—axe and chisel.

The writer has seen a post-boy, whose sledge was broken by an upset, go into the forest, cut a branch, and in an hour have new and neatly morticed and tennoned spars in the place of the broken ones, without use of screw or nail. The method of using the axe is somewhat wasteful of both time and timber, but as both these

commodities are superfluities in the north, this is but a small disadvantage. To obtain a plank, a peasant fells a tree or branch, and chops away at it until but a plank remains; it never occurs to him that with a saw, four such planks could be obtained with less labour from the same tree. Nails and screws are luxuries anywhere in Russia; but in the north they are absurdly dear, owing to the bad methods adopted by the over-protected home manufacturer, and to the impossibility of importing at a reasonable rate. In Penega—a city of furs and timbers just south of the Arctic circle — roughly-finished soft iron nails, and no screws, are obtainable, and these at a price which should show a good profit on well-made steel screws. Axe-heads are equally dear; knife-blades of decent temper almost unprocurable; and this in a land where iron and coal abound at but little depth below the surface, where labour is cheap, and where the knife and axe are national implements: truly the Russian Customs tariff outdoes that of America. The skill of the peasant, both in making and using his knife, equals that with the axe. From an old file, or even a bit of hoop-iron, he will grind a knife-blade, fix in a piece of reindeer-horn for a handle, and can then fashion almost any object from a piece of wood. Some, too, have a good idea of making models in this way; the writer has before him a model of a Samoyede lady and gentleman in their sledge, made by a peasant friend. The harness is of sealskin, but man, wife, deer and sledge were cut in a very short space of time out of a piece of firewood with a home-made knife. Gun stocks, one of the most difficult tasks that can be set before a carpenter, are renewed with the knife and axe, and are often good reproductions of the original in point of size, shape, and "bend," but, as the villagers have only access to soft wood, such as deal, birch, or at best ash, they are apt to split before long.

Birch bark is a useful material to the peasants. From it, after submitting it to a partial tanning process, they construct all kinds of vessels. They have a clever method of dovetailing, or rather plaiting, together the seams in such a way as to be absolutely watertight. This can be seen in the illustration on p. 42, Fig. 7, which shows a pail such as is used to carry milk, kvass (the native beer), or water, bought in the open-air market in Vologda. Such bark vessels, besides being lighter, have two advantages over metal, for they are not only watertight if the contents are fluid, but allow of some slight expansion if it freezes, and bark can be touched in the coldest weather with the naked hand, whereas a blister or frost-bite would inevitably result from contact with metal. The second view, Fig. 8, of this milk-pail shows well the crude conventional designs with which the mujik ornaments his handiwork, designs which are seldom original, but generally slavish copies of the ideas of his forefathers, but whose gaudy colours make up fully for the lack of designing power. This use of bark, instead of metal, is very characteristic of the northern part of the Empire, for the use of iron seems always to be avoided if any substitute can be found; chain, for instance, except that bought for ships' use, is almost unknown, rope being used in its place. The use of copper and brass is more general than that of iron, and most houses have samovars, jugs, and basins of these metals. China is but little seen, save in the towns, its place being taken by wood for plates and dishes. The forest has given so much and so liberally, it has discouraged the use of metals to so marked an extent, that the Russian can be said to be a carpenter or nothing. Such china as is on sale is brittle, and but poorly ornamented; probably it is for this reason that pottery ware is so much used. Earthenware utensils are produced after much the same methods as were those of ancient Egypt. Some few peasants find a living, or rather a part of their living, by the practice of this ancient art: they dig up the clay in autumn, when the ground is soft, and lay it in mounds near their homes, where it lies, frozen, but handy for the winter's work. When wanted for use, they knead it up with the finely-ground remains of old broken earthenware and sand, so as to prevent it from cracking when heated. After this mixture is

brought to a proper consistency, it is fashioned by hand, left to slowly dry in the heat of the living-room for some days, and then baked in an oven. The peasants often make delf for their own domestic use in this way, and heat it in their own cooking ovens; but those who make it for sale have specially constructed kilns, and some village communes have made ditch-like furnaces which are common to all inhabitants. The delf is glazed on the outside, but is generally left rough on the inner, which renders it hard to clean when this operation is considered necessary. This outside glazing is done with the object of rendering earthenware, which is naturally porous, watertight; when performed by the peasants in their own homes and for their own use, the very simple method of throwing rock salt over the articles, while in the oven, is adopted: the salt volatilises and decomposes, a fusible sodic silicate being formed on the surface of the vessels. When done on a larger scale in special ovens, a somewhat more elaborate method is used: glass, felspar, or flint are powdered up and made into a paste with water, and thinly spread over the surface to be glazed; under the influence of heat this coating fuses, and forms an insoluble glassy varnish, through which liquids cannot pass. Northern clay is either very poor in silicates, or the method of manufacture is very bad; for the resulting hardware is but little better than our flower-pots, although of a darker brown colour.

Now that the making of candles has fallen to such small proportions in England, the melting of tallow in Russia has likewise decreased; but a large quantity is still refined by the Mujik, partly for use as "rush lights," for they can scarcely be called candles, and partly for leather dressing; for much leather is dressed white, with a great amount of tallow rubbed into it, in order to prevent it from freezing, and to enable it to better withstand damp.

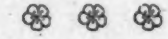
Russian baskets differ much from ours, and are worthy of notice. They are made of plaited strips of soft white wood, about $\frac{1}{8}$ in. thick and $2\frac{1}{2}$ ins. wide, woven in and out, just as are the rush and osier strands in our baskets. The top and bottom are strengthened with bands of birch tied in with juniper or willow strands, thus making them very strong and light. Covered boxes made in this way are used by travellers by sledge, where, very literally, they play the double rôle of "a bed by night, a chest of drawers by day," for one must sleep on the top of one's luggage, which is covered only by a stratum of hay, whose depth is dependent on the length of one's tip to the driver.

With these, and such as these, employments, and with fishing, snaring, shooting, sealing, and the like, do the Mujiks of the Great White Tsar fill up the time during which snow, rain, and flood render purely agricultural work on their allotments impossible; but it is to the land—be it rich Siberian grain land, Finnish fen land, desolate Arctic "tundra," or primeval forest—that the poor Slav chiefly looks for the little all that makes his somewhat dreary life worth living. The communal allotment—the few acres of pasturage and tillage which every male upon the village census list may call his own—is dearer to the heart of the true Russian than any form of trade or merchandise. "The Tzar"—he will tell the stranger who talks with him—"the Tzar is our father, but the land is our mother."

Ernest. Ward. Lowry

The Edinburgh Cable Tramways System.

By BENJAMIN TAYLOR



THERE are many features of peculiar interest about the tramway system of Edinburgh. In the first place, Edinburgh is one of the most beautiful and picturesque cities in the world, and is visited by people from all climes because of its physical attractions and its historic and romantic associations. In the second place, it is the capital of Scotland, and therefore the centre of the professional and official—though not of the industrial and commercial—life of the Northern Kingdom. In the third place, it has adopted cable traction when it is being abandoned almost everywhere else where it has been tried for street railways. In the fourth place, the installation is the most complete and perfect system, and also one of the largest systems, of cable tramways to be found anywhere in the world. In the fifth place, Edinburgh is the only city in the country which has adopted cable traction on all its lines. And in the sixth place, the Edinburgh system is a remarkable example of constructive ability, and of mechanical ingenuity in overcoming difficulties which elsewhere have been found practically insuperable. We do not propose to compare the Edinburgh system with that of other towns, nor to discuss the relative merits and demerits of cable, electric and animal haulage. The purpose of this article is merely to give a description of the mechanical and general features of a peculiarly interesting undertaking. The work of construction occupied over four years, and the cable system in Edinburgh now covers some 42 miles of double track, or say about 21 miles of street.

That Edinburgh should adopt what some people regard as an obsolete system of traction has caused a good deal of surprise and comment in the mechanical world. But whether or not the choice was wise the explanation is simple. The Modern Athens is essentially one of the show places of the kingdom. It has a pride of local beauty and national interest which causes its citizens to consider it as something apart from and superior to the common work-a-day world and the general run of cities. Other towns may sacrifice much to utility, but Edinburgh will not sacrifice her "amenities" to anything. Therefore, Edinburgh would not and could not tolerate, on any consideration, the overhead trolley system for electric traction. The idea of trolley wires and iron pillars breaking the fine perspective of its classic thoroughfares was anathema, and the great initial cost of the electric-conduit system was not agreeable. Moreover, Edinburgh is very hilly—though perhaps not more so than, say, Sheffield—and Professor Kennedy, himself an electrical expert, recommended to the Town Council cable haulage as best adapted to the physical and æsthetic conditions of the place. The story of the Battle of the Motors is a long one—too long for our pages—and, as usual in all controversies of the kind, a great deal of heat was generated and a considerable amount of bitterness was diffused. But after prolonged discussion and conflict the cable system was decided on by a majority of the Town Council and it is now *in esse*.

Of course, one reason for the adoption of the cable system by the Corporation of Edinburgh, when it was resolved to municipalise the tramways, was that a cable line already existed in one part of the city and had given satisfaction to the citizens. This was the line constructed and operated by the Edinburgh Northern Tramways Company, at right angles northward to Princes street. The rest of the city was served by a horse tramway constructed and operated by the Edinburgh Street Tramways Company. When the Corporation decided to take over the whole system,

both companies were bought up, and the entire system has been converted into cable by the municipality, except one very short branch line still worked by horse haulage. But the Corporation, though it has acquired and converted the whole system, does not operate the tramways, as the Corporation of Glasgow does. The completed undertaking was leased to Dick, Kerr & Co., Limited (who were largely engaged in the reconstruction work), who in turn incorporated the Edinburgh and District Tramways Co., Limited, to carry out the terms of the lease. That lease covers the whole track, buildings, plant, machinery, &c., and is for a period of 21 years, from 30th June, 1898. The lessees are to maintain, repair and renew the road and plant, and conduct the service to the satisfaction of the Corporation. They are to pay, in name of rent, interest at the rate of 7 per cent. upon the capital outlay, a sum of £350 per annum for expenses of inspection and oversight, and all the feu-duties and ground annuals payable by the Corporation in respect of the properties held in connection with the tramways.

The fares must not exceed one penny per mile, inside or outside—"or such smaller rates as may be from time to time agreed upon between the Corporation and the second parties"—and cars are to be run at certain hours for the working-classes "at fares or rates not exceeding one penny for the first two miles or part thereof, and one halfpenny per mile or part of a mile beyond." And though cabling has been adopted there is provision in the lease for alternative motors.

As a municipal enterprise the Edinburgh Tramway System is peculiar and complicated, but the foregoing will suffice to generally indicate the position. The cost of buying out the two companies and of reconstructing has exceeded one million sterling. The actual total cost cannot yet be fully stated, but no expense has been spared to make the work thorough, and in carrying out along with it certain street improvements.

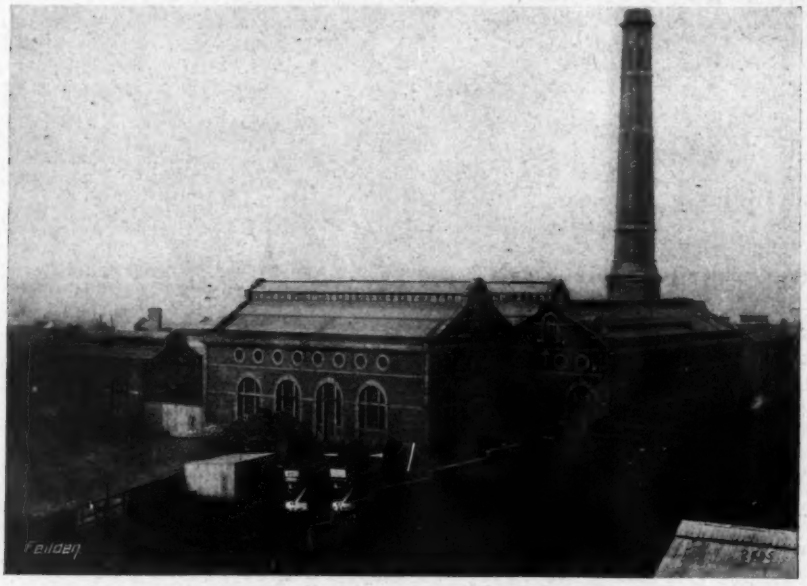
The work of construction has been carried on under the personal supervision of Mr. W. N. Colam, who, as Engineer to the Corporation, continues to supervise the undertaking operated by the lessees. And here we have to express our obligations to Mr. Colam for furnishing the technical material for this article. Mr. Pitcairn is the General Manager for the Company.

If Edinburgh is not a city of magnificent distances like Glasgow, it is one of many and heavy gradients and of innumerable curves. And the curve, although the line of beauty, does not tend to the simplification of street railways. The whole city, indeed, may be said to be set not on a hill, but on a hill-side, sloping down from the historic old town towards the waters of the Firth of Forth. Back of the Old Town, again, the surface is heavily undulating. Practically the only long level track is that which tourists see first, and most of, viz., the run east and west along the line of Princes Street. Even casual visitors will remember how that level breaks away at the east end in the long slope down to Portobello, and the still deeper descent into Leith. The gradient from the Post Office down to Leith Street is one in 16, that on The Mound is one in 11, and that from Princes Street down towards the Botanic Gardens (a route which has long been worked by cable by the Northern Company) is one in nine. These are, perhaps, the steepest gradients, but there are several others almost as bad, and many of them are very long.

The numerous curves and junctions have been dealt with in a very effective fashion. One thing successfully overcome has been the necessity, which prevails on other systems, of the curves having to be rounded at full speed—often to the danger of the traffic and the inconvenience of the passengers. This is got over by the adoption of short, slow-speed auxiliary cables, and by the use of a new type of gripper. On the Edinburgh system a car can be brought to a stand promptly on the sharpest curve and started again promptly without the slightest difficulty. Auxiliary cables are provided at the following important junctions :— Post Office and Register House, Princes Street (west end), Haymarket, Morrison Street and Earl Grey Street, Morningside Road and Churchill, Grange Road and March-

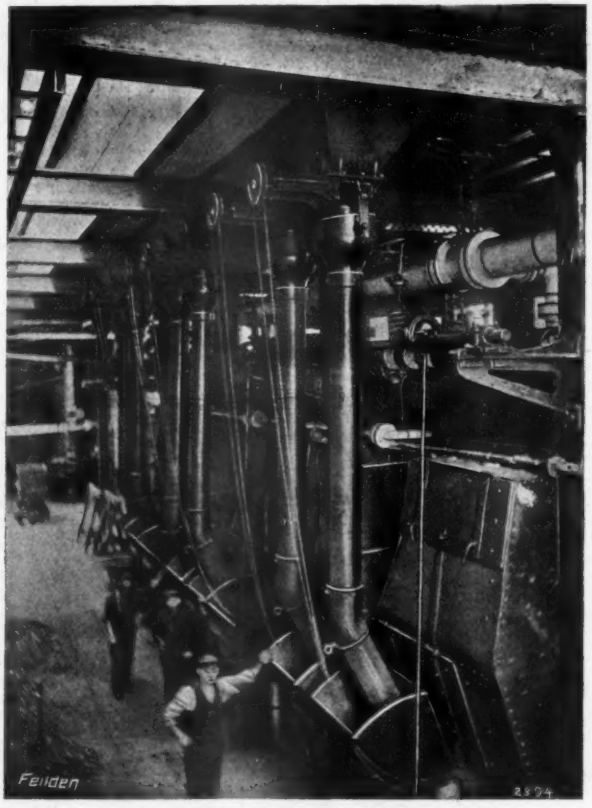
mont road, Newington Road and Grange Road, Princes Street and St. Andrew Street. At these junctions the main cable is turned back under the other track, returning round a large vertical pulley at one end of the curve. Upon one side of the shaft of this pulley is mounted a smaller pulley for the auxiliary cable, which is made to overlap the main cables on both roads. and to traverse the curve. When a car arrives from either side at the curve it is brought to a stand, the main cable is dropped from the gripper and passing aside owing to a slight diversion of the rails allows the gripper to seize the auxiliary cable. By an arrangement of cross-overs at these junctions, the cars can, when desired, be returned down the main line without rounding the curves. As there is not much tension on the auxiliary cable it is kept constant automatically by means of a vertical pulley in the pit sliding in a frame supported between the roofing and the floor. When the cables cross at the junctions it is always the auxiliary that is uppermost, the main rope being diverted underneath and upwards again by means of pulleys. A car going straight on and not rounding the curve catches the main cable again in less than its own length.

Every visitor to Edinburgh knows the Register House and the great commingling of four lines of traffic at that busy centre. As will be readily understood, this is the most important and complicated junction of the cable system. The lines cross north and south, east and west, and cars coming from east or west must be able to go either north or south as well as straight on. Therefore three auxiliary cables are used, and the main cables do not cross at all at this point. The one coming up from Leith Street is taken by a separate subway across under Princes Street into the North Bridge conduit, just where the auxiliary cable is returned. The returning portion works the pully that drives the auxiliary which takes the cars between



EDINBURGH CABLE TRAMWAYS: THE SHRUBHILL DEPÔT.

Leith Street and North Bridge. The other main cable terminates at the Register House and on the return gives the motion for the auxiliary cable which works both the curve into the North Bridge and the straight crossing into Waterloo Place. Between Leith Street and Princes Street the cars make use of both auxiliary cables. The work of construction here, it will be seen, was very complicated and called for all the ingenuity and resourcefulness of the engineer, who may well be proud of the manner in which he has overcome unprecedented difficulties. A difficult part of the work was in making the pits, which are roofed partly by iron trough-plates on which the permanent way and cable conduit are constructed; and partly by arched plates with a central slot to which the slot rails are fastened, at the parts immediately above the cable returning pulleys.



STOKER ROOM AT SHRUBHILL.

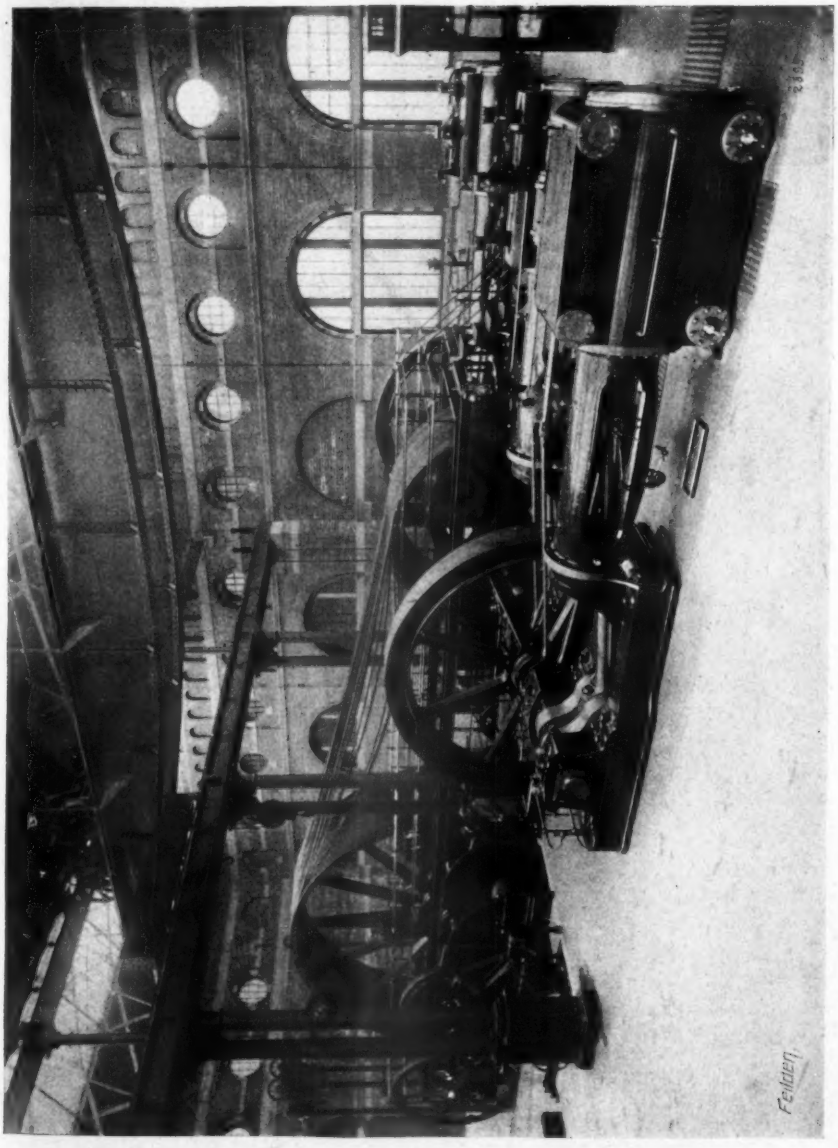
At each suburban terminus are two large vertical pulleys– one in front of the other and slightly tilted. Coming in on the top of the first pulley the cable passes under it and then over the top of the tilted pulley. A conduit carries the returning portion along the cross-over

track to take the car over to the return line. As the car arrives and the gripper is opened the cable is deflected aside, and the returning portion is ready to be picked up in its place.

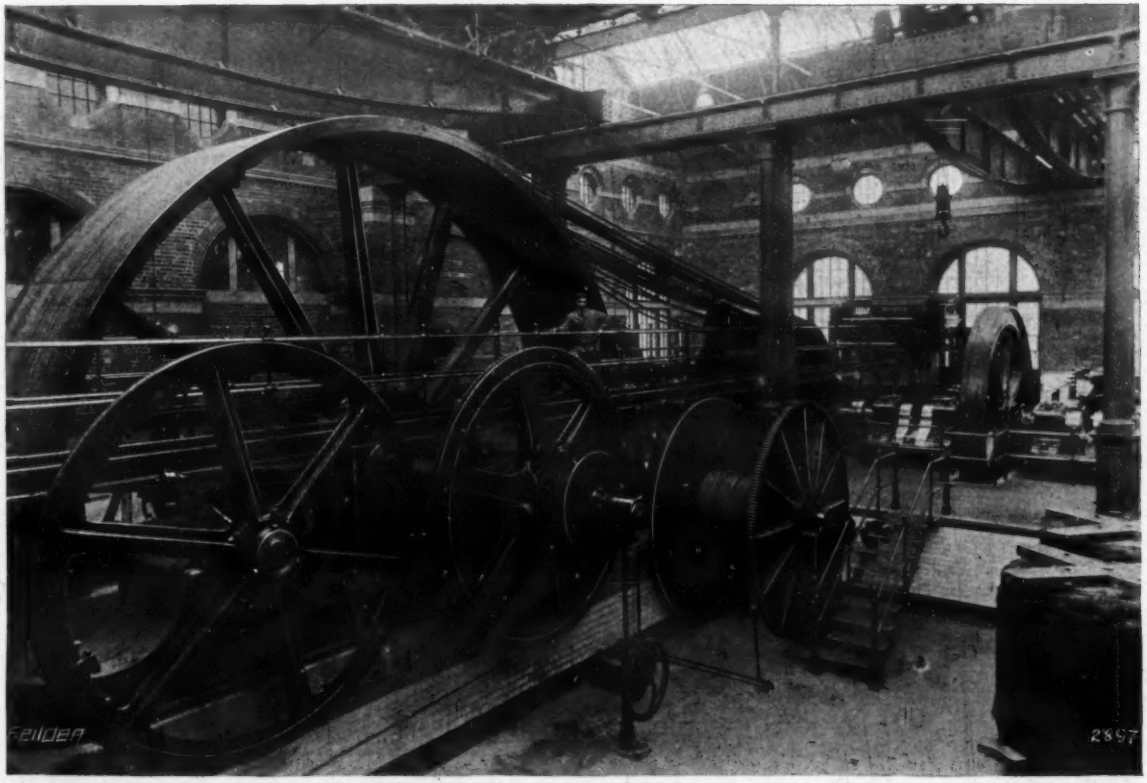
The gripper is necessarily a feature of the greatest importance in any cable system, and that in use at Edinburgh is of peculiar interest. Almost everything depends upon it. The numerous junctions require that the gripper shall have two pairs of jaws, one on each side of the shank. There is a gripper on each car platform and each gripper has two pairs of jaws. This is necessary because the cable is carried sometimes on one side of the slot line and sometimes on the other, and because at crossings the car has sometimes to be hauled backwards for a short distance by the rear gripper manipulated from the front. And the gripper is placed slightly in front of the axle of the foremost wheel, instead of behind it as in the usual bogie arrangement. Mr. Colam has devised a most ingenious flexible arrangement of the screw apparatus by which both a lateral and a circular motion of the gripper is provided, so that any curves can be easily taken. Near the gripper box is a small lever, by means of which the driver can throw his front gripper out of gear and bring into gear the gripper at the other end, which can then be worked from the front platform. To leave the main line at a junction and pass into a branch line the driver opens the front gripper, and the car is brought to a standstill in front of the facing points, the gripper is opened two turns, and the main cable flies out to resume a normal straight line from which it has been temporarily taken by means of a kink in the slot. The gripper is then opened two or three turns more, and is closed upon an auxiliary cable with the other side of the gripper, and the driver can then proceed through the points and round the curve on an auxiliary cable travelling at a reduced maximum speed of four miles per hour. At the end of the auxiliary cable the gripper is again opened two turns, and the cable naturally flies out, and the main cable is in a position to be taken by the other side of the gripper again. The operation of releasing one cable and taking another can be performed in from seven to eight seconds, and is practically automatic.

There is another operation which has to be performed at junctions, namely, in passing straight on the main line where the main line cable has to dip under an auxiliary cable passing through the curve. This operation is performed in the following manner: Cars arrive at the junction driven by the cable in the gripper at the rear end of the car, and the car is stopped at a place which puts the front gripper of the car on the other side of the auxiliary cable. The driver then lets go the main cable in the rear gripper, and takes it in the front gripper and leaves on the main cable again. This operation has frequently been done in 15 secs., but the usual time varies between 20 and 25 secs. At this place the cables are arranged to leave on opening the gripper, and the cables to be taken up again are placed so that the gripper gets hold of them without any mechanical assistance from the surface of the road.

The motive power is now provided at three power stations, one of which—that at Henderson Row—has for a number of years worked the short line of the Edinburgh Northern Tramways Company, now absorbed in the Corporation system. At this power station, however, an additional pair of engines of 350 h.p. has been erected, and a third cable-driving pulley. The Northern Tramways Company had two cables working the Golden Acre and Stockbridge routes. These are still retained, but a third cable has been put in to work the Golden Acre route up to Princes street, which it crosses in a conduit to The Mound, where it runs into an open conduit for working the cars from The Mound along George IV. Bridge to Tollcross. Nevertheless, the Golden Acre route terminates where it did under the Northern Company, just at the junction on the north side of Princes Street, and The Mound forms a terminus for the Tollcross route, though the same cable works both. This cable is 18,800 ft. from Henderson Road to Tollcross and back.



EDINBURGH CABLE TRAMWAYS: ENGINE-ROOM AT SHRUBHILL.



EDINBURGH CABLE TRAMWAYS: ANOTHER VIEW OF THE ENGINE ROOM AT SHRUBHILL.

As the principal power station is at Tollcross, we will confine our description to that. It drives five cables by machinery compacted into the very limited space which the Corporation could allot in this district. The building itself is a handsome one, though out of any line of thoroughfare. It is chiefly of red brick, with a main front of red freestone, and the whole buildings cover an area 600 ft. long, but not exceeding 230 ft. in breadth at the broadest part. One part of the building is in two storeys, the lower for the tension races and the upper for car-sheds into which the cars are hauled up an incline by an auxiliary cable.

The engine-room is very lofty, and contains three pairs of horizontal compound non-condensing engines, with cylinders working side by side. These cylinders are — high pressure, 23 in. diameter, and low pressure 40 in., with a 5-ft. stroke. Each pair of engines is of 500 h.p. with a steam pressure of 160 ft. per sq. in., and a speed of 45 revolutions per minute. The variation in speed with full and empty loads does not exceed 4 per cent., and cannot vary more than 10 per cent. even were the load suddenly doubled. Only two of the engines are required, the third pair being held in reserve. There are four boilers, of the marine type, 10 ft. 6 in. in diameter and 12 ft. long, set so as to use up the heat of the furnace gases to the fullest extent before they enter the main flue. Great economy is effected by passing the gases four times along the length of the boiler. Berriman-Wright feed-water heaters are used. The cylinders of the pumps, which are vertical double-acting, are of $10\frac{1}{2}$ ins. diameter and 18 ins. stroke. There are two independent feeds from the pumps to the boilers—the primary through the feed-heaters and the economiser, and the secondary direct from the pumps. All the boilers can be fed with hot water, or all with cold water, or some can be fed with either, or some or all can be fed with both. The coal is stored in lofts above the boilers, and is let down through pipes to the hoppers of the Vicars mechanical stokers. All the piping is duplicate throughout, and is passed through subways between the boiler-house and the engine-room.

To return, however, to the operating machinery. The main shaft is divided by couplings into sections and carries three fly wheels of 16 ins. diameter, and also two driving pulleys, $14\frac{1}{2}$ ft. in diameter, arranged for 32 cotton $1\frac{5}{8}$-in. ropes. On the counter shaft are two grooved drums, 30 ft. in diameter, over which the ropes pass. On the counter shaft are also five cable-driving pulleys for driving the five cables, each pulley 10 ft. in diameter, and with a deep grooved rim for gripping the cable. Part of the cables pass round an idler pulley which gives a grip to them round the driving pulleys.

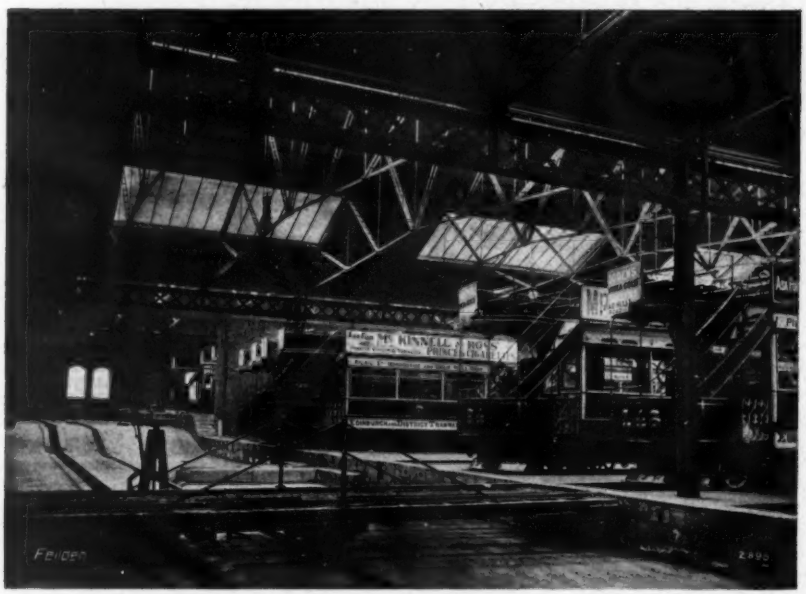
There are auxiliary 70-h.p. engines of the inverted vertical type, which are used for moving the cables slowly at night for purposes of examination and repair, and for starting new cables. A Lindsay coil clutch on the countershaft enables the driving pulley to be quickly thrown out of gear, and also moderates its speed. The tension races for the cables have not the usual excavations because the movable tension carriage and pulley are set horizontally, and the tension-carriage rails are laid upon supports some 3 ft. above the floor. The weights, instead of hanging behind the tension-carriage, are hung by tail-ropes on the wall of the engine-room, where the engineer has thus constantly before him an index of the fluctuations of the load on each line.

The cables are carried out by a subway to a pit, where they are directed by pulleys on their several courses. The five cables operated from the Tollcross power station run respectively, by Morningside to the Braid Hills and back; by Melville Drive and Grange Road to Newington and back; by Churchill, Morningside and Marchmont road; by Lothian Road, Princes Street and Maitland Street to Haymarket and back; from Haymarket to Murrayfield; and by Morrison Street and Dalry Road to the Gorgie terminus and back.

The third power station is at Shrubhill, which may be regarded as the central station, though it is smaller than Tollcross. This used to be the site of the stables and car-sheds of the horse tramways, and it is

520 ft. long by about 170 ft. broad. Here also a good deal of attention—and money—has been devoted to architectural embelishment. The internal arrangement of the buildings is much the same as at Tollcross, already described, except that there are only two pairs of engines and three boilers. One set of engines is operated (the other being kept in reserve) to drive two cables. One cable runs up Leith Walk, York Place, and South St. Andrew Street to Princes Street, and is 20,000 ft. long; the other works the cars from the Leith boundary to Nether Liberton and is six and a-half miles long. At Shrubhill are also repair and machine shops, repairing pits, carpenters' shops, etc., for the whole system, and there are also arrangements for working the whole of Leith, when Leith comes into the metropolitan system.

The fourth power station is at Portobello and was the last to be constructed. It is also the smallest of the four. It has two sets of tandem horizontal compound engines (one for reserve) from which the power is transmitted to the countershaft by spur-gear wheels, which is a less expensive method than the rope-drive gearing adopted elsewhere. The engines are of 350 h.p. and the cylinders are 20 ins. and 32 ins. in diameter with a 4-ft. stroke. These boilers are somewhat smaller than those at Tollcross. Two cables are driven from Portobello Station. One runs to Joppa and back and is 13,000 ft. long, and the other runs to the Register House and back and is 35,000 ft. long.



EDINBURGH CABLE TRAMWAYS: TRAVERSER FOR RUNNING CARS INTO SIDING.

The total length of all the cables is 256,358 ft., say 48½ miles. The total engine-power provided is 4,100 h.p., which is claimed to be very much less than would have been required for the same car service with electric traction, and is calculated to be equal to 24 h.p. per car. As, however, about 1,500 of the h.p. is held in reserve for emergencies, the actual power in use is equal to about 15 h.p. per car.

The cars are the joint design of Mr. Colam, the Engineer, and Mr. Pitcairn, the General Manager, and that they are more than usually spacious and handsome may be inferred from the fact that they cost £445 each. This, however, includes the cost of the gripper and relative outfit. The platforms are roomy enough to admit of the entry and egress of both inside and outside passages at the same time. The cars are on two bogies of four wheels each, the bogies being of light steel. The track is of standard gauge, but the distance between the centres of the wheels is only 3 ft. 9 ins. The overend length of each car is 26 ft. 6 ins., and they are seated for 20 inside and 28 outside. They are panelled with plate glass instead of with window sashes, and they weigh under five tons each. Some of them were built by Brown, Marshalls & Co., Limited, Birmingham, and some by G. F. Milner & Co., Limited, Birkenhead.

The work of constructing the track was begun in the suburbs and gradually carried along the various lines of route into the centre of the city. By this means interference with the working of the horse-car service was reduced to a minimum. Indeed, there was little interruption, for as only about a couple of hundred yards of single track were dealt with at a time the horse-cars were easily shunted by means of temporary cross-overs past the broken bits of road. Thus the horse-cars were kept running during the whole time until the cable tracks were finished, but of course the work in such circumstances took a good deal longer than if the track had been laid new throughout. The first permanent way contract of about 21 miles was completed by Messrs. Dick, Kerr & Co., Limited, within twelve months.

The foundation of the track rails is of concrete, and the rails were renewed throughout, although some of the old track had been only recently relaid. The rails are in lengths of 32 ft. and weigh 83 lbs. to the yard. They are, of course, of steel, subjected to very severe tests. The joints and fish-plates were the first of the kind introduced into this country, and other cities have since adopted their construction. The fish-plate is 24 ins. long, and for about half its breadth the tread of the rail is cut away. One fish-plate is carried upon this side flush with the tread; there is no break in the tread of the rail across its breadth but at each end of the fish-plate and at the joint of the rail. It is claimed that the weight of the car is thus distributed equally between the rails and the top part of the fish-plate. The fish-plates are secured by six bolts, 1 in. each in diameter, and by a method of countersinking which brings the head of the nut in perpendicular line with the edge of the rail head, by which means the cutting of nut holes in the paving setts is avoided. The slot rails weigh 48 lbs. per yard, that is, 96 lbs. per yard for the pair, and are the same as those adopted on the Brixton cable tramway.

The cable conduit is of the familiar type. It is 19 ins. in depth from the top of the slot, and to the bottom of the concrete is a total depth of 26 ins. The cable-carrying pulleys in the conduits are also of the familiar type. They are set vertically on the straights, and horizontally or obliquely, as need be, on the curves. On two sections, where the streetway is too narrow for a double track, Mr. Colam has devised an ingenious method of getting rid of the disadvantages of a single track with passing places. This is by means of an interlacing line which brings the rails of each track hard up against the other and the guard of the one rail is countersunk into the tread of the other. At the joints the two rails are bolted together through the fish-plates. One great advantage of this is that the noise of track points is avoided. One cable conduit serves the single track, both outgoing and incoming portions of the cable running into it, each on its own set of pulleys, separated by a space of two or three inches. The double-jawed gripper can grip the cable in whichever direction is required. It is claimed that by this system the wear and tear on the single track should be no greater than on a double track.

A similar, but yet in some respects different, arrangement is adopted for a service line from the main track into the car-shed at Thornybank. This service

line passes down a lane only 20 ft. wide, in which room has to be afforded for cars to pass each other as they come into or go out of the shed.

The re-paving of the track has been entirely with new material, both between the rails and for 1½ ft. on each side of them. Most of the paving has been done with Quenast quartz, specially dressed so that the blocks fit both close together and close up to the rails. The setts are 3 ins. wide, 9 ins. long, and 5 ins. deep inside the track, and 4 ins. by 6 ins. by 9 ins. outside the rails. The joinings are grouted with bitumen filled up with cement—a combination to preserve a waterproof bottom and prevent the disagreeable surface caused by melting pitch in hot weather. This paving work has been very expensive, but it is expected to be very durable, and it ensures a smoothness that reduces the noise of vehicular traffic to a minimum. Of 30,000 tons of paving setts used 19,000 tons were from the Quenast quarries, and the rest from Aberdeen and Wales. In a few special localities where it was necessary to still further reduce the noise of traffic, wood paving has been employed.

The arguments in favour of the cable system for Edinburgh may be thus summarised. Edinburgh is a city unique in configuration of ground and in defined lines of buildings. It has had twelve years' experience of cables on the Northern system and has been satisfied with the mechanical and financial results there. At the time of choice there were no reliable data available upon which the financial aspects of an electric system suited to Edinburgh could be judged. And Edinburgh could in no circumstances adopt any system, like the overhead trolley, that would injure its beauty.

This is not to say that the choice is universally approved, either in the press or among the citizens of the Northern Capital. On the contrary, it is still severely condemned by some, and the working of the new system is being jealously watched by keen-eyed critics ready to pounce upon any mechanical defects or financial objections. For one thing, the cable system is declared to be not flexible enough for the peculiar configuration of Edinburgh streets. Then it is alleged that a system so rigid cannot be extended, if desired, beyond the city boundaries. That is a question for the future to decide; but Edinburgh does not throw out tentacles in all directions, like a common industrial town growing with its own industries, and perhaps it is not undesirable to restrain municipal enterprise within municipal boundaries. As to cost, it may be that the cabling of the Edinburgh system has cost more than was expected or was absolutely necessary, but at any rate the total outlay has been less than would have been inevitable with the electric conduit system.

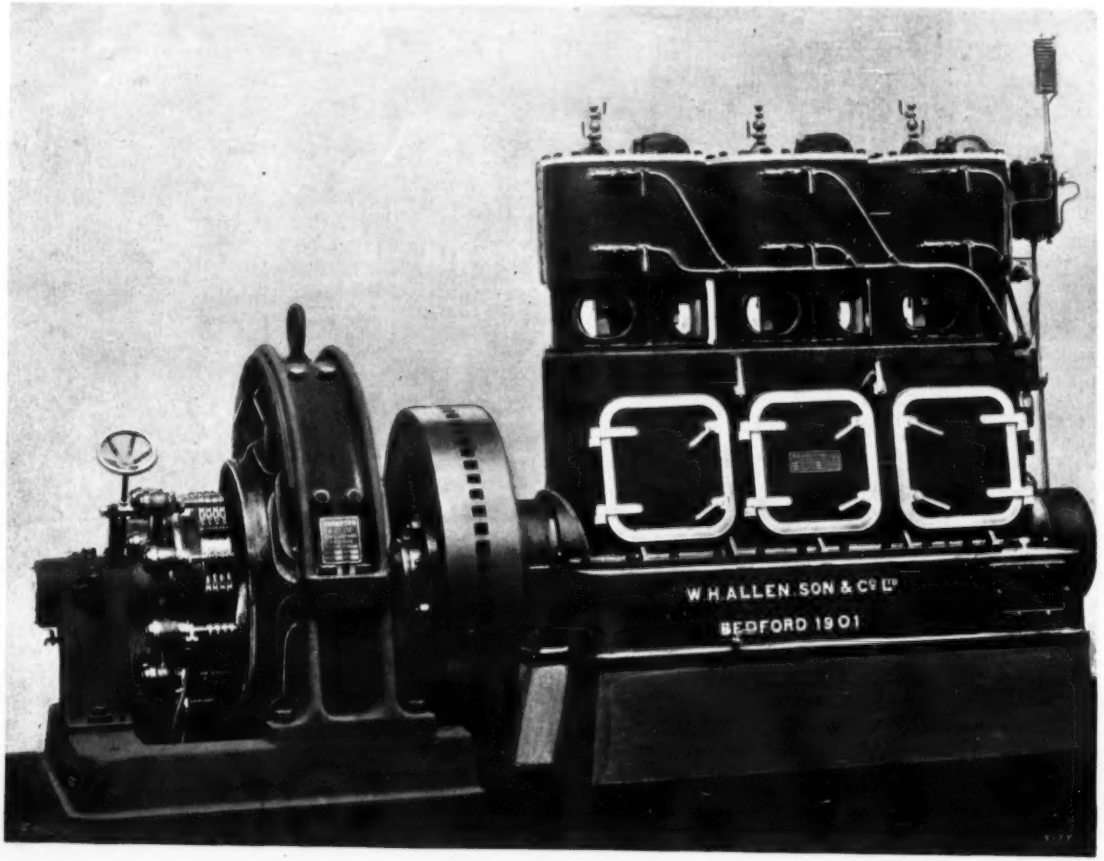
As to the cost of working, the experience yet has been too short to judge, but it is expected to turn out cheaper than by the use of electric power owing to the very large number of very steep and long gradients which are a feature of the Edinburgh system. On these gradients power is conserved on the cable by the descending cars assisting the ascending cars, whereas extra electric energy would be required to propel the cars up the ascents. It is, however, unnecessary now to discuss whether or not Edinburgh has made a a good choice. Whether for good or evil, the choice has been made and the results must be accepted. As a new departure in an old mechanical system, the undertaking is full of interest for all, and for engineers especially in respect of the ingenious devices employed and the skill with which difficulties have been overcome.

P.S.—Since this article was written litigation has arisen between the Corporation of Edinburgh and the lessees on matters relating to the equipment of the system and the management of the service. The controversy is beyond our province—besides, the dispute is still *sub judice*. Reference is made to it here because, in the course of the statement just laid before the Court of Session by one of the parties, it is stated that the capital expenditure has reached £1,200,000, and that a further sum of £92,000 is estimated to be required to complete the system.

BENJAMIN TAYLOR.

SUP

Supplement to
FEILDEN'S MAGAZINE,
January, 1902.



MACHINERY APPLIANCES AND PROCESSES.

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Machinery, Improvements, Novelties, etc., for inclusion under this section. No charge whatever is made for the publicity afforded or for illustrations, nor is any *quid pro quo* expected. FEILDEN'S MAGAZINE undertakes the whole of the cost, merely stipulating that proper details, photos, blue prints or tracings are supplied. If necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

A NEW STANDARD 3-CYLINDER COMPOUND ENGINE.

THE engine represented in our Supplement plate is of the three-cylinder compound double-acting type, specially designed for high speeds, uniform turning moment, and efficiency under varying conditions of load. This type of compound engine has been designed in the first instance for electric light, power and traction work, but it is equally useful for general purposes, where high-speed direct driving is essential.

The length of the engine bed is 94 ins., width 54 ins., and height from lower edge of the baseplate to the top of cylinder covers 86 ins. The small space occupied by this engine for the power given out is worthy of note, and, as will be seen from the tests, particulars of which are given below, there is no sacrifice of efficiency, while the steam consumption compares favourably with, and is, in fact, better than many first-class two-cylinder compound engines of the same power. The engine is fitted with a governor acting direct on the throttle valve, with a view of reducing the variation in speed to a minimum in the event of the whole or any portion of the load being suddenly thrown on or off, the stop-valve remaining full open under all conditions. This engine is one of many already completed or in course of completion in the works of Messrs. W. H. Allen, Son & Co., Ltd., Bedford, and is shown coupled direct to a Crompton multipolar shunt-wound direct-current generator, of the nominal output of 460 volts and 435 ampères. The field magnets, of which there are eight, are made of the best cast steel. The yoke ring is made in halves, accurately faced at the joints, and rigidly bolted together. The winding on the magnet consists of eight coils of double cotton-covered copper wire, the shunt connections between the shunt coils being made by short cables attached to suitable eyes. The armature is of the drum type with slotted core, which is efficiently ventilated. The armature winding consists of a number of conductors of high conductivity copper carefully insulated and varnished, and connected to the commutator by means of separate copper lugs. The end connections are made by bending the conductors to shape on a special block before securing the armature core, the coils being in this way made interchangeable and easily renewable. The commutator of the machine is built up of hard drawn copper segments, and is of sufficient depth to allow of at least one inch of wear before requiring renewal. The segments are insulated from one another and the bush by mica, and are firmly held together round the bush by screw pressure. The collecting gear consists of eight brush spindles, each fitted with a set of holders provided with carbon brushes. The outer bearing of the dynamo is of cast-iron, fitted with removable cap and cast-iron bush lined with white metal, the bush being of a spherical shape, so as to readily align itself with the shaft, and the bearing is made self-oiling by means of oil-rings, the oil being carried in a reservoir in the base of the pedestal, from which it may be drawn by a cock.

The engines are being made in various sizes according to the requirements. In this instance the size of the high-pressure cylinder is 11 ins. diameter, and each of the low-pressure cylinders is 15 ins. diameter, the stroke in each case being 9 ins. It is designed for a speed of 450 revolutions per minute, and to develop 320 i.h.p. with a steam pressure of 150 lbs. per sq. in. at the stop-valve.

The crank-shaft is forged from a solid bloom of Siemens-Martin steel, and the eccentrics are solid with the shaft. The angular distance between the cranks is 120

degs. The material of which the crank-shaft is made is steel, having a tensile strength of 28 to 32 tons per sq. in., with a minimum elongation of 30 per cent. on a 2-in. length, the length of the measured test portion being 3·5 diameters. There is considerable advantage in having the crank-shaft and eccentrics solid at high speeds, as the number of independent moving parts are reduced to a minimum.

In order that the high speed may be maintained for a considerable time, the engine is fitted with a system of forced lubrication after the well-known manner adopted by this company, a small pump of simple and efficient design, driven direct from the engine, being placed inside the bedplate for this purpose.

The cylinders are made of a special mixture of close-grained hard and tough cast-iron, the tests showing a tensile strength of 12 to 15 tons per sq. in.

The valves are of the solid piston type, and take steam on the inside edges, thereby diminishing the pressure on the glands as compared with valves taking steam on the outer edges.

The governor is of the centrifugal kind with controlling springs fixed direct on the end of the crank-shaft, and revolving with it. It is connected by means of an arrangement of levers to the throttle-valve, which is immediately above it, and is so arranged that the speed of the engine can be varied by the attendant, if so desired, within 5 per cent. above and below normal speed while the engine is running.

On a trial made at the Queen's Engineering Works on November 2nd, 1901, carried over a period of six hours, the mean steam consumption for this period was 16·4 lbs. per i.h.p. per hour. The mean steam pressure at the stop-valve was 150 lbs. per sq. in., and the mean speed 451·3 revolutions per minute.

The steam consumption was measured by the water received from the air pump of the surface condensing plant installed for testing purposes in the works, direct into two tanks which had been carefully calibrated, enabling the exact weight of water used to be found without trouble and with great accuracy.

TRIAL RESULTS, 11" and 15" and 15" by 9" ENGINE.

Mean steam pressure ...	150 lbs. per sq. in. at stop-valve
Mean r.p.m.	451·3
Mean i.h.p.	308·8
Mean e.h.p	261·5
Total water per i.h.p. per hour	5 074
Lbs. of water per i.h.p. per hour	16·4
Lbs. of water per e.h.p. per hour	19·4
Mean vacuum during test at engine exhaust ...	24 ins. mercury.

With reference to the governor, we give a series of results showing the behaviour of the engine during the removal of full, three-quarter, half, and quarter load.

GOVERNOR TRIALS (STOP-VALVE FULL OPEN).

Variation of load.	Mean speed before throwing off load.	Revolutions per minute. Maximum and minimum speed reached after removing load and before settling.		Settling speed.
		Maximum.	Minimum.	
Full to no load ...	448	475	—	453
¾ to no load	448	472	—	461
½ to no load	445	470	—	464
¼ to no load	483	473	463	460

In the case of the full load test, the mean speed at the moment before breaking the circuit was 448 revolutions per minute.

On throwing off the whole load, amounting to 261·5 e.h.p., the speed rose steadily to 475 revolutions per minute, and then settled at 453 revolutions per minute. The duration of time from throwing off the load to settling being about five seconds. It will thus be seen that the maximum variation of speed was 5½ per cent., while the settling speed only shows a rise of one per cent. above the mean speed.

For the three-quarter load test the mean speed at the moment prior to the removal of the load was 448 revolutions per minute, which, on breaking the circuit, rose to 472, and settled at 461 revolutions per minute, the time occupied being about 4 seconds.

For the half-load test the mean speed of the engine was 448 revolutions per minute prior to the removal of the load, which rose to 470 on breaking the circuit, and settled at 464, the time being about 4 seconds.

For the quarter-load test the mean speed, which immediately before the removal of the load was 453 revolutions per minute, rose to 473 revolutions per minute on breaking circuit, fell to 463 revolutions per minute, and settled at 460 revolutions per minute, the time occupied being rather less that for half-load.

THREE-PHASE INSTALLATION AT PALMER'S SHIPBUILDING WORKS.

ONE of the most recent and important electric power installations is that now in constant use at the works of the Palmers' Shipbuilding and Iron Company. This old-established firm is world-famed, and its reputation is held in the highest esteem in all engineering circles. The large works at Jarrow-on-Tyne have facilities for the building of all classes of ships. The multitude of men and processes which combine to produce an ocean liner or a battleship from Nature's original raw materials are collected, under the name "Palmer," on the southern bank of the Tyne. Here are all classes of engineering trades, and departments ranging from blast furnaces to finishing shops for the finest work. Mineral ores and lumber enter; the smartest vessels afloat depart. Two of the largest branches of these works are to be dealt with in this article—the engine department and the shipbuilding department, in which electricity is the sole power agent in use.

Hitherto the many metal and wood-working shops, and the various yard appliances derived their power from an army of small steam-engines supplied from several banks of steam boilers located here and there about the works. The steam-eating propensities of such a power arrangement for works of this description are notorious. The expense of maintaining a sub-divided steam-plant, compared with the cost of the operation of an electrical power system applied to the same purposes is enormous. This is easily understood when one considers that even the nature of the power supply was one which did not conduce to the efficient operation of either boilers or steam-engines. The great number of boilers and engines constantly running during working hours, for the greater part of the time at very light or under no load at all, entailed a great waste. The condensation in the long lengths of steam piping required to supply the numerous engines, the want of flexibility of those pipes, the space occupied by the many boilers and steam-engines, the labour required for their constant operation, the losses occasioned by the long lengths of overhead shafting and belting, etc., etc.—these are all

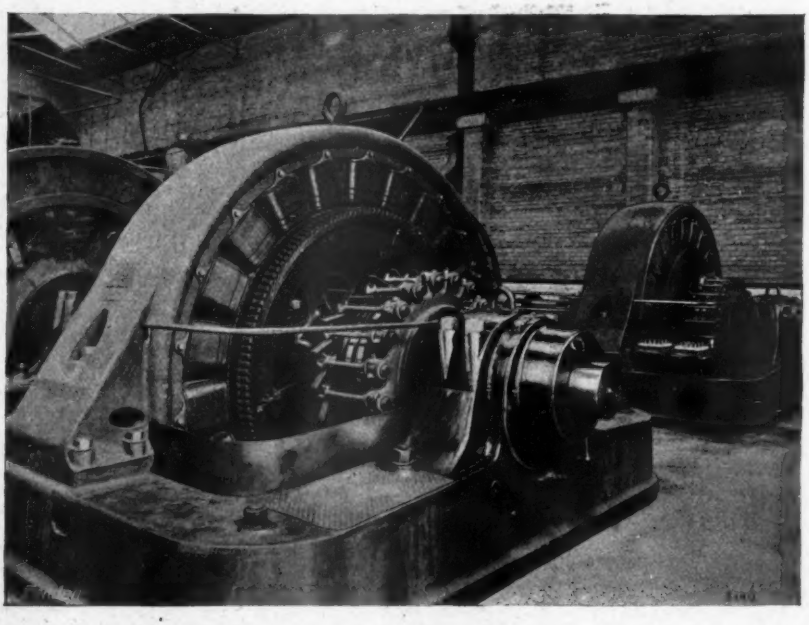


FIG. 1.—MESSRS. PALMER'S SHIPBUILDING WORKS: WESTINGHOUSE THREE-PHASE ALTERNATORS.

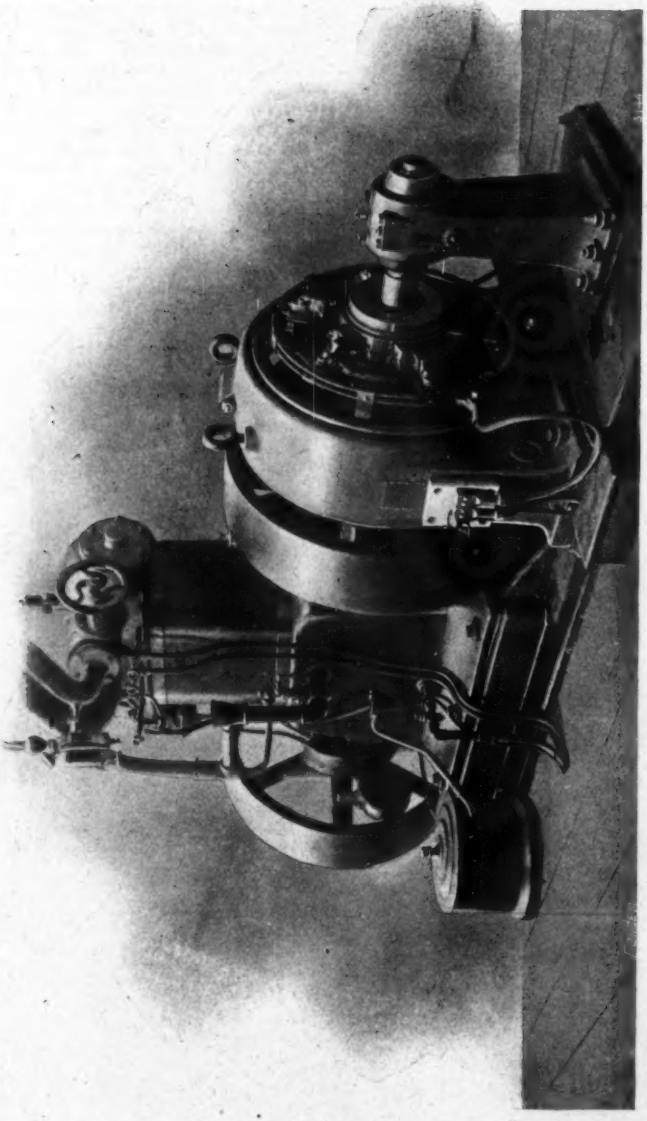
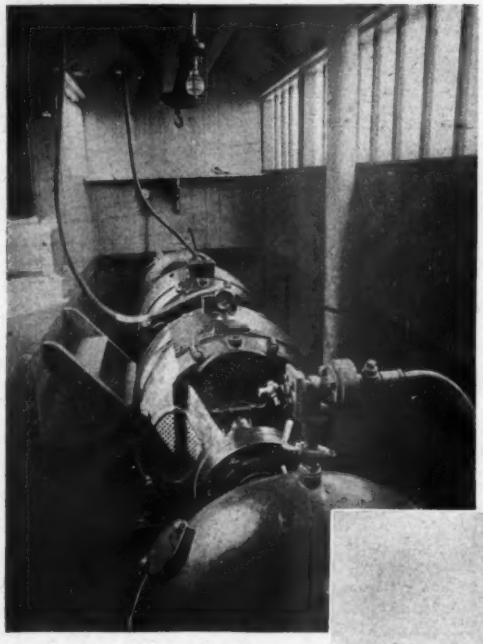


FIG. 8.—MESSRS. PALMER'S SHIPBUILDING WORKS: WESTINGHOUSE DIRECT-COUPLED EXCITING SET.



FIGS. 3 AND 4. — MESSRS. PALMER'S SHIPBUILDING WORKS: WESTINGHOUSE INDUCTION MOTOR DIRECT-COUPLED TO PUMPS AND MOTOR OPERATING A WINCH.

important points which help to bring about the gross inefficiency of such a system as was used in the shipbuilding and in the engine-building departments of the Jarrow works. Remembering what has been said, it will be easily gathered from a description of the works as they stand to-day what great improvements have been effected.

The whole of the power required for the operation of the two departments under notice is generated in one central power-house, wherein are located the boiler plant, the steam-engines, the electric generators, and their auxiliary appliances. The power-house is a new building situated near the centre of the area to be supplied with electric power. A dividing wall across the centre isolates the boiler plant from the engines and dynamos. The boilers at present installed consist of four Lancashire boilers, working at a normal pressure of 150 lbs. to the square inch. These boilers are hand-fired, and three out of the four are kept constantly in use to supply the works load. A small auxiliary steam-engine is installed for driving the economisers, scrapers, and the two feed-pumps in the boiler-house. With this exception the whole of the steam generated is utilised for driving the main electric generating sets. The main generating sets are two in number, of equal sizes. Each consists of a triple-expansion, open-type, vertical marine engine of 1,000 h.p. capacity. These engines operate condensing, and run at a normal speed of 160 revolutions per min. Between each engine and its electric machine are two additional bearings, between which a 22-ton flywheel, 11 ft. in diameter, runs. The connection between the engine and the flywheel is by a flexible coupling. On the other side of the flywheel the electric generator is direct coupled. The latter in each

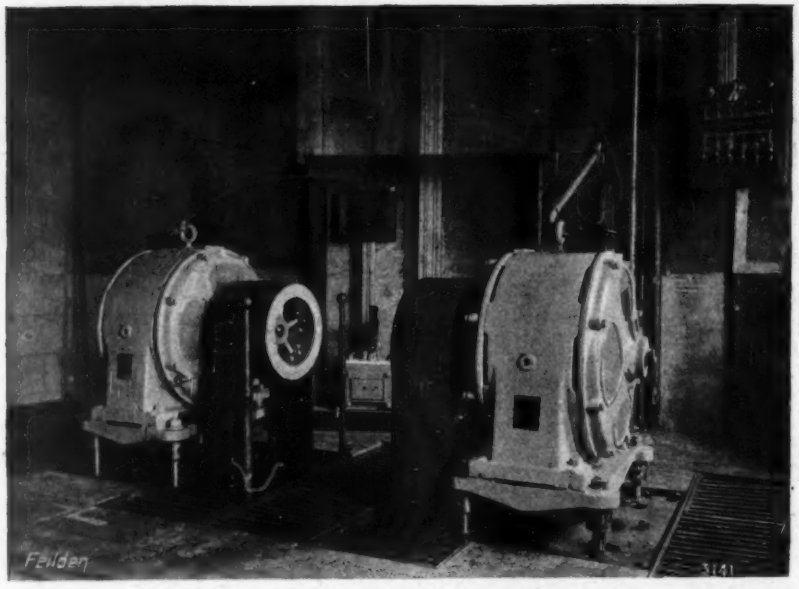


FIG. 5.—MESSRS. PALMER'S SHIPBUILDING WORKS: WESTINGHOUSE INDUCTION MOTORS DRIVING DRY-DOCK PUMPS.

case is a Westinghouse three-phase alternator, yielding 750 kilo-watts at a pressure of 440 volts. This alternator is of the rotating armature type, and is built in accordance with the well-known standard Westinghouse designs. The field consists of a circular ring, with 22 internally projecting pole-pieces. The pole-pieces are built up of soft steel stampings cast into the field ring, which is horizontally divided to give easy access to all internal parts of the alternator. Each of the 22 pole-pieces carries a coil of the field winding. These coils are machine-wound on formers, which slip easily over the pole-pieces, and are held in position by lugs secured to the field ring by set-screws. The armature is of the "iron-clad," or "slotted-core" type. The core is built of soft steel stampings assembled on a cast-iron spider, which is pressed and keyed on the shaft. The conductors are of copper rod, cut into suitable lengths, and insulated before being placed through the core-slots. The armature end connections are of copper strap bolted to the ends of the conductor bars. This form of construction ensures perfect uniformity of insulation for the armature windings, and permits of the easy inspection and removal of any part without disturbing more than the one actually required. Ample provisions are made for cool running. The armature spider is traversed by cored passages, and the core stampings are so arranged that a continuous stream of air is forced round the windings, and through the core, while the machine is running. The machines have, consequently, a very large overload capacity. Overloads of 50 per cent. can be easily maintained for a considerable length of time, and overloads of 75 per cent. can be accommodated without damage to the machine. The arrangement of the generating sets, and some idea of the construction of the alternators will be gathered from Fig. 1. Exciting current for the main generators is generated by either of two direct-coupled exciting sets. Each of these consists of a Westinghouse compound steam-engine with cylinders 8 ins. and 13 ins. in diameter respectively, and a stroke of 8 ins., direct coupled to a Westinghouse multipolar direct-current generator of 25 kilo-watt capacity, yielding a pressure of 250 volts when running at the normal speed of 375 revolutions per min. Each of these exciting sets is capable of supplying exciting current for both the two main generators together.

The main switchboard consists of five marble panels, viz., two generator panels, one exciter panel, and two feeder panels

The circuits are arranged for the parallel running of the alternators. Each of the feeder panels bears the instruments, switches, etc., for a main feeder, one for supplying the engine works department, the other supplying the shipbuilding department. Two smaller feeder circuits run from the engine department panel, one to an auxiliary board, also placed in the power station, and from which circuits radiate to various motors placed in the immediate neighbourhood; the other auxiliary circuit supplies current direct to a pair of motors, each of 40 h.p. capacity, direct-coupled to centrifugal pumps (see Fig. 3). These pumps are installed in a small shed by the water side about 80 yds. from the power house. They supply the water for the condensing plant of the main steam engines. The total lift of these pumps at low water is about 25 ft., and each one is capable of providing sufficient water for a maximum load on the whole of the power plant. The practice is to run each one continuously on alternate days. The switches for the starting of the motors are arranged alongside the motors. The motors supplied from the auxiliary board in the power house are: a pair of 50-h.p. motors, each driving by belt a dry dock centrifugal pump (see Fig. 5); a 20-h.p. motor driving a winch for general lifting purposes on the jetty; two other 8-h.p. motors driving similar winches, and one 8-h.p. motor driving a portable boring gear. All the other motors throughout the works are supplied by current from either of the two main feeders.

The engine works department feeder is a three-core cable, each conductor having a section of 0·33 sq. in. This feeder runs direct from the power house to a switchboard in the machine-shop of the department. Here it is put on to a set of bus bars through a 1,000-ampère switch, from which bus bars the circuit is split up into five parts. Each of these five circuits terminates at a distributing board placed at convenient centres in the works for current distribution. At each of these distributing boards a similar process of subdivision is carried out, current is put through a main switch on to a set of bus bars, from which, through other switches, the various individual motor circuits are run. It will be seen that this arrangement gives simplicity to the whole of the wiring system, and also preserves the independence of each motor, rendering a total breakdown practically an impossibility.

The first distributing board from the

FIG. 6.—MESSRS. PALMER'S SHIPBUILDING WORKS: WESTINGHOUSE INDUCTION MOTOR DRIVING SHAFTING.

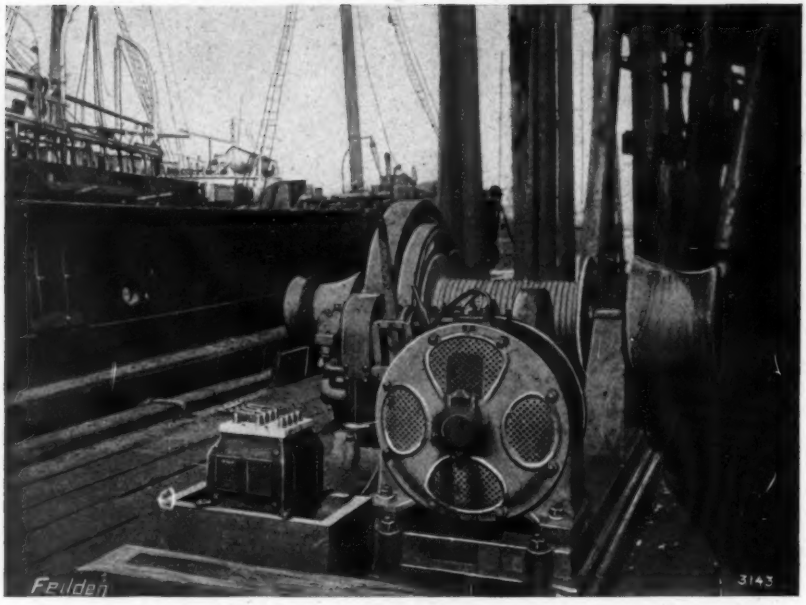


FIG. 7.—MESSRS. PALMER'S SHIPBUILDING YARD: WESTINGHOUSE INDUCTION MOTOR OPERATING A WINCH.

engine works department feeder is situated alongside the main feeder board in the machine shop. There are in all nine motor circuits on the machine shop distributing board. Two motors of 30 h.p. each, one of 25 h.p., and one of 20 h.p. are installed in the machine shop, and drive the various lengths of overhead shafting by belt. Some of these are set on the ground others are bolted at the side to the columns of the building. A 15-h.p. motor drives by belt a fan providing draught for the smithy hearths. In another branch of the machine shop a 10-h.p. motor is put down for driving a very large boring mill. The overhead travelling cranes are being converted for electric driving. Two of these will be single-motor cranes, and two new three-motor cranes are being installed. A winch, driven by an 8-h.p. motor, is also supplied from the machine shop switchboard. It is placed just outside the shop in the yard, and is used for general hauling purposes.

Another distributing switchboard is situated in the erecting shop. This board has thirteen motor circuits radiating from it. The motors installed in connection with it are: a 15-h.p. motor, driving a large planing machine and two large lathes; a 10-h.p. motor, driving a large milling machine; a 40-h.p. motor, coupled to an electric arc-lighting dynamo, and a 30-h.p. and a 10-h.p., coupled by belt to overhead shafting for the operation of various small machine tools. From the board in the erecting shop run the circuits for a 30-h.p. motor which drives the whole of the plant in the top fitting shop, and also the circuit for a 15-h.p. motor driving all the machinery in the brass machine shop. Other motors to be supplied from this board are a 30-h.p. for the pattern shop, and a smaller one for operating a metal-breaker in the yard.

The distributing board in the foundry has five motor circuits. In the foundry, two 50-h.p. motors are installed. One, hanging from the ceiling, drives two blowers, and the other, on the ground, drives two sand-mills. Three 20-ton cranes are supplied with power from a 20-h.p. motor. This arrangement is, however, temporary. There are, in all, six cranes in the foundry, and these are all to be fitted with an independent motor, each fed direct from the distributing board. From the foundry board leads also run to two 20-h.p. motors, installed in the copper shop, one driving a fan, and the other the overhead shafting. A 15-h.p. motor, installed in the

jetty fitting shop, is also supplied from this board.

The main feeder between the power-house and the shipbuilding department terminates at the switchboard in the No. 2 shed. The circuits of the shipbuilding department are arranged in a similar manner to those of the engine works department described. At the feeder-board in shed No. 2, the main circuit is split up into five portions. One of these is led to a distributing board alongside the feeder-board. The motors installed in No. 2 shed are: two of 50 h.p. each, which drive by overhead shafting the various punching, shearing, planing, bending and rolling machines in this shed, where plate work is undertaken. Two sets of rolls installed in an adjoining shed are also driven by these motors, the overhead shafting extending through the intervening wall for this purpose. Another distributing board has eight motor circuits radiating from it. One feeds a 30-h.p. motor, by which half the plant in shed No. 1 is driven. In this shed plate-work is also carried out, the machines installed being principally rolls, punches, shears, drills, etc. Other motors supplied from this board are two of 20 h.p. and four of 8 h.p., which drive winches for the raising of materials to vessels on the stocks. In shed No. 3, angle ironwork is carried out, the machinery being principally squeezers, punches, and shears, each being separately driven by motors. The distributing board in this shed bears 11 switches. The motors at present supplied from this board are a 30-h.p., driving an air-compressor for riveting machines, etc.; a 10-h.p. motor, driving a large combined punch and shears; a 5-h.p., driving a horizontal angle-bar cutter and squeezers; three of 5 h.p., driving combined shears and punches; a 5-h.p., driving a portable angle-bar beveller; a 5-h.p., driving horizontal squeezers; and a 15-h.p. motor, driving a horizontal fan for smiths' fires.

In addition to the 30-h.p. motor already mentioned, installed in shed No. 1 and supplied from the distributing board in shed No. 2, there is another 30-h.p. motor in shed No. 1 supplied from a board installed there. This motor drives the remainder of the plate-working plant in the shed. Other circuits radiating from this board pass to a 10-h.p. motor, driving plant in the plumbers' shop, and to other motors supplying power for circular and band saws in the pattern shop and for three 8-h.p. winches. The winches are used for hauling heavy forgings on trucks, for hoisting materials aboard, and for general lifting at the jetty side. The joiners' shop is fitted with two distributing boards. From one of these two motors, each of 30 h.p., driving overhead shafting are supplied, and also one 15-h.p. motor operating a jib-crane for lifting heavy logs of timber. Two motors of 30 h.p. each are coupled to the other board. They drive by belt a large frame saw and other wood-working machinery.

A separate distributing board is installed for splitting up the circuits to supply the various machine-tools distributed about the yard. The motors connected with this board are one of 8 h.p. coupled to a winch, for hauling vessels into dock, seven of 5 h.p. each, driving punches and shears, one of 5 h.p. driving horizontal squeezers, and another of 5 h.p. driving combined squeezers and angle-iron cutter. Another shop well fitted with electric motors, for the most part applied individually to machine-tools, is the shipyard fitting shop. Here are installed a 50-h.p., a 40-h.p., and a 30-h.p. motor, driving the overhead shafting for running the various smaller machine tools. In addition, there are seven small motors; one of 5 h.p. drives squeezers; three of 8 h.p. each are coupled to winches for hauling purposes; two of 5 h.p. each drive combined punches and shears; and one of 10 h.p. drives a fan for a small forge.

Altogether, there are over 80 motors installed in the two departments under notice. Their total h.p. has an aggregate of over 1,500. The motors are all exactly similar in construction. They are of the form known as the Westinghouse type "C" Induction Motor. Those of 20 h.p. and upwards were supplied by the British Westinghouse Electric and Manufacturing Company, Limited; the smaller ones were built by Messrs. Clarke, Chapman & Co., under Westinghouse licence. This motor is in very general use for practically all power purposes, and it has been so frequently described at length that it is unnecessary in this article to dwell upon the details of its construction. It is particularly adapted for the driving of engineering tools and machines in dirty and exposed positions. There are no commutators or sliding electrical contacts of any description. The only windings of the motor are stationary, and these are insulated throughout their length, and may be electrically coupled and insulated without any break between the motor and the supply mains. The electrical circuit of the rotating part consists simply of a series of stout copper bars carried in slots on the periphery of the core, and short circuited at each end by two massive copper rings, to which they are securely bolted. The whole of the rotating part is thus a rigid and simple mechanical

arrangement. The smaller sized motors—those of 10 h.p. and less—are started by switching direct on to the 400-volt mains. The larger ones have what is known as an "auto-starter," in conjunction with a two-way switch for starting. With the switch in the first position, small reducing transformers are placed between the supply mains and the motor, the motor receiving the starting current at a reduced pressure. When speed is up, the two-way switch is thrown over to the second position. The motor is thus put direct on to the 400-volt main, and the starting transformer cut out. The transformers of the "auto-starter" are arranged with additional leads brought out from the secondary coil, so that the secondary voltage used may be that which gives the best starting torque for the conditions under which the motor is to work. This is adjusted once and for all for each motor. The starting switches and auto-starters are placed closed to their respective motors. Those of the motors installed in the open air are placed in sheet-iron waterproof boxes secured to some part of the frame of the machine tool being driven.

Comparing the present electric power system with the steam system superseded, one is at once convinced of the enormous saving in operating expenses which must result from the change, and although no actual figures of comparisons dealing with Messrs. Palmers' installation are available, it is acknowledged that a very considerable saving has resulted from the change. The power equipment is of exceptional interest to engineers, since it affords examples of the several principles on which electric power may be applied to the driving of works machinery.

Thus, where many machines located together are in continuous use day by day they have, for the most part, been arranged to take their power from common shafting supplied by one or two large motors. Where the machines are exceptionally large, or where they are in isolated positions, or where they are only used for short times together, a separate motor has been provided for each machine. Works whose electric equipment is arranged according to these two principles tend to make the most from their electrical system. At Messrs. Palmers', however, there was one other condition which prevented them from taking full advantage of those principles. The old steam plant was, for the greater part, worn out. New power apparatus was absolutely necessary, and the works were exceedingly busy. Thus it was essential that some system should be put down which would interfere to the least extent with the continuous operation of the works. The present system was put down with that in view, and the work continued in every department during the change of the power system without any noticeable interruption.

MADISON PARK BRIDGE.

DESIGNED BY H. G. TYRRELL, C.E., BOSTON, MASS.

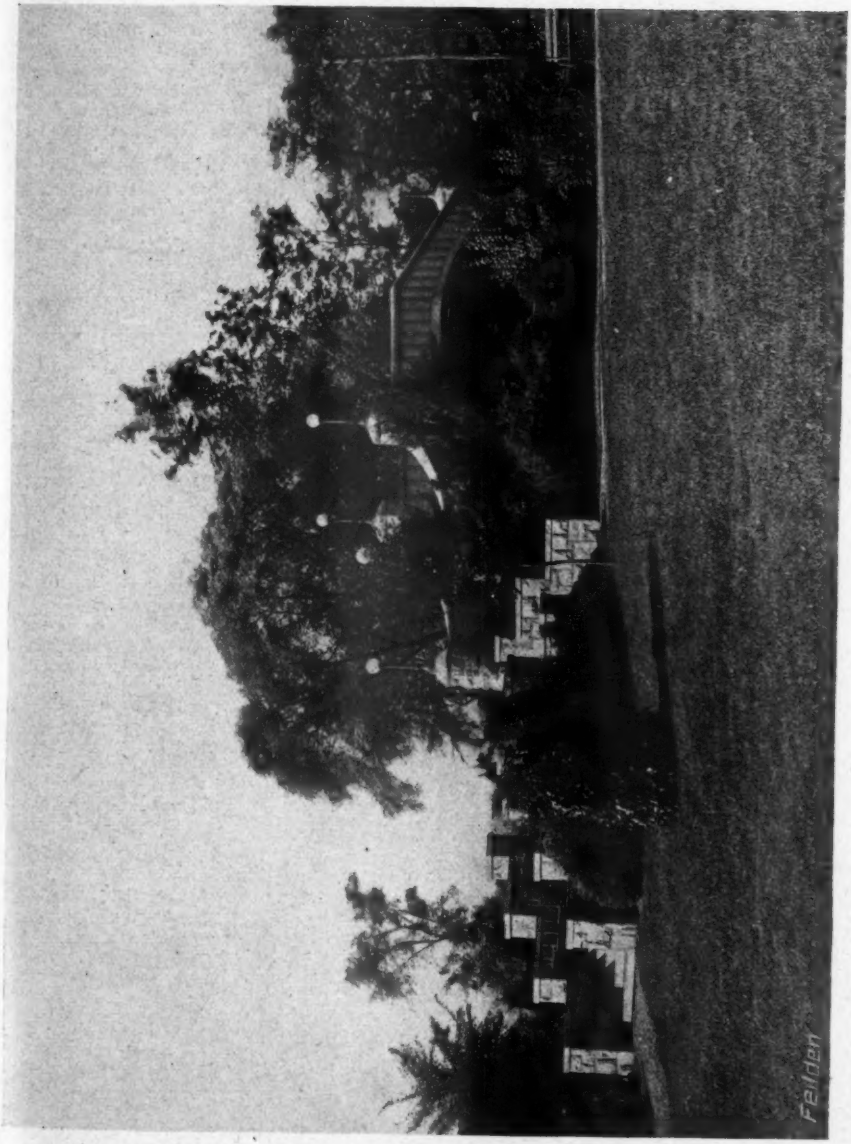
THE accompanying photograph illustrates an ornamental bridge recently built at Madison, N.J. It spans two lines of railway where it crosses the park in a deep cutting. The centre part of the bridge is a steel plate girder, built in the form of an arch. It has a span of 50 ft. clear and a width of 10 ft. The two plate girders are connected at the bottom with light beams, and between these are laid curved sheets of corrugated iron. The girders are held in a vertical position by gusset-plates riveted to stiffeners on the web and fastening to the floor beams. Beneath the floor beams are cross braces in the plane of the bottom chord, and at each end there is a vertical cross frame. The girders are capped with heavy cast-iron handrails. On the outside of each girder there is built a projecting steel fascia, to represent an elliptical arch, thin at the centre and increasing in thickness towards the abutments.

The abutments are built of ornamental stonework, and at each end there are two cast-iron electric lamp-posts and globes.

The whole structure is surrounded with plants and shrubs, and presents altogether a pleasing appearance.

MOVING A LONG BRICK WALL.

THE first portion of the New York Rapid Transit Railway structure which was completed ready for the track rails, was a section a few hundred feet long on Broadway, north of West 135th Street. It was constructed (says the *Engineering Record*) of the standard dimensions and design for two tracks, but as recent developments have made it desirable to have three tracks at this point for the operation of the railway, the Rapid Transit Commission authorised the contractors to change it to a three-track structure, and this work is now in progress. At about 135th Street the tracks begin to descend northwardly from the surface of the ground to enter the underground section, and there is an inclined entrance in open cut to the beam-construction subway. The bottom of

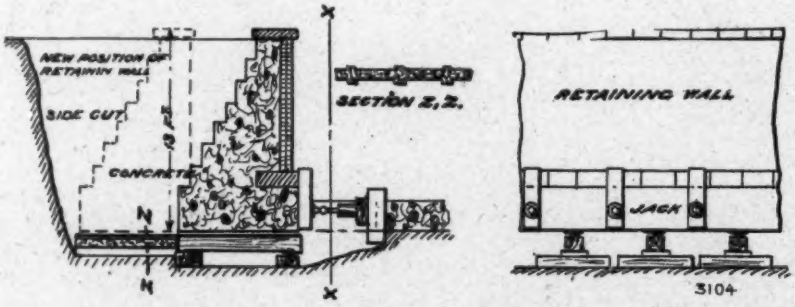


PARK BRIDGE AT MADISON, N.J., DESIGNED BY H. G. TYRRELL, C.E., BOSTON, MASS.

the cut has a solid concrete floor, continuous with the footings of the retaining walls on each side. It was decided to cut through this floor parallel, and adjacent to the face of each wall, and to move each wall backward parallel to its original position 5½ ft. farther away from the centre line, to permanently seat them in their new positions, and to restore and extend the concrete floor between them, so as to secure the wider structure without destroying the original masonry.

The retaining walls are about 196 ft. long, and from 4 ft. high at the south end to 13 ft. high at the north end, and 3 ft. thick on top, battering with irregular offsets on the rear to a maximum bottom thickness of 8 ft. They are faced with 9 ins. of brickwork, built with one course of pressed brick and one of red brick, and have a line of footing stones built into the concrete base under the brickwork at floor-level. After removing the concrete floor close to the wall, and making on the opposite side an excavation about 6 ft. wide at the bottom, small holes were worked through the earth under the footing, and 12 in. by 12 in., transverse timbers, about 8 ft. long, were set in them from 3 ft. to 5 ft. apart, according to the height of the wall. A 5 in. by ½ in. steel track-plate, 13 ft. long, was laid on top of each timber, and 5 in. by ½ in. sliding pieces, 12 ins. long, were laid across them longitudinally, under the front and rear edges of the footing. A 10 in. by 16 in. longitudinal sill was laid flat under each end of the transverse timber, and the latter was given bearing on them by driving a pair of thin oak wedges side by side on top of each sill. The sills were so long that their ends nearly touched in the middles of the spaces between the transverse timbers, and practically formed two continuous bearings, each 16 ins. wide, under the wall. Back of the wall a concrete footing, 5½ ft. wide and 6 ins. in minimum thickness, was laid with deeper transverse ribs on the centre line of the track-plates, which were 1 in. above its upper surface, and bedded in cement mortar. The oak wedges were driven until the wall was slightly raised, and after the concrete footings had set a week or more, jack screws were placed horizontally from 3 ft. to 6 ft. apart against bearing pieces on the foot of the wall and on the edge of the concrete floor, and, being simultaneously operated, in a few hours pushed the whole length of the wall 5½ ft. transversely to bearing above the new footing.

The screws were turned at given signals, and great care was taken to keep the wall lined in, so that no transverse strains or distortions were developed A transit was set up and a sight taken parallel to the axis of the wall, a few inches from the required position of its face, and offsets were taken from it to make sure that the wall should not be moved too far, and to check its position. At the end of the moving the wall was found to be less than $\frac{1}{16}$ in. out of line or level, and no cracks or injuries could be discovered. Where the wall was highest the blocking had settled a little and given the sliding plates a slight upward inclination, and the face of the wall had to be raised slightly to plumb it. The space of about 1½ in. between the top of the new concrete footing and the bottom of the old wall, which was left between the sliding plates for clearance of the irregularities of the concrete, was grouted, the timber removed, the steel track-plates cut off flush with the face of the wall, the excavation backfilled, and concrete put in to restore and extend the floor. The estimated weight of the wall was about 200 tons, and the preparatory work and moving was accomplished in ten days by twenty men, under the direction of the Terry & Tench Construction Company.

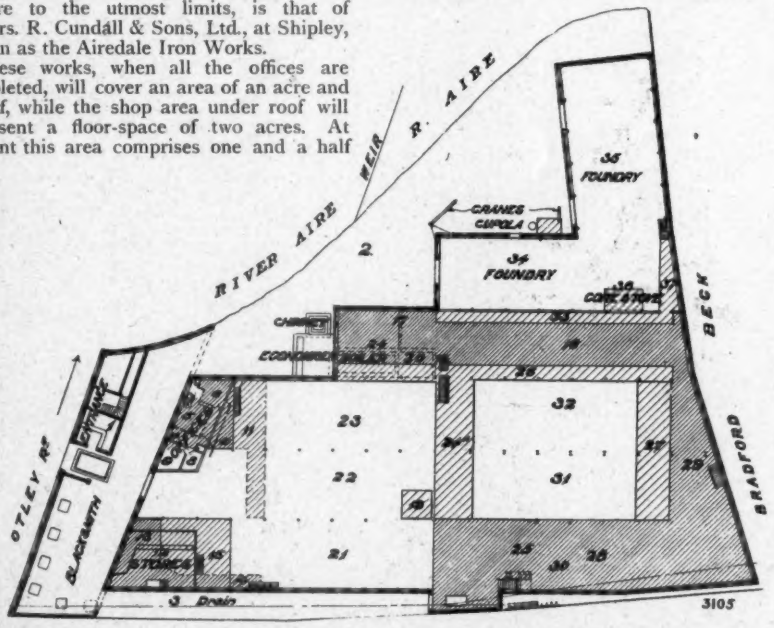


HOW GREAT BRITAIN IS MEETING FOREIGN COMPETITION.

3.—Specialisation.—Contd.

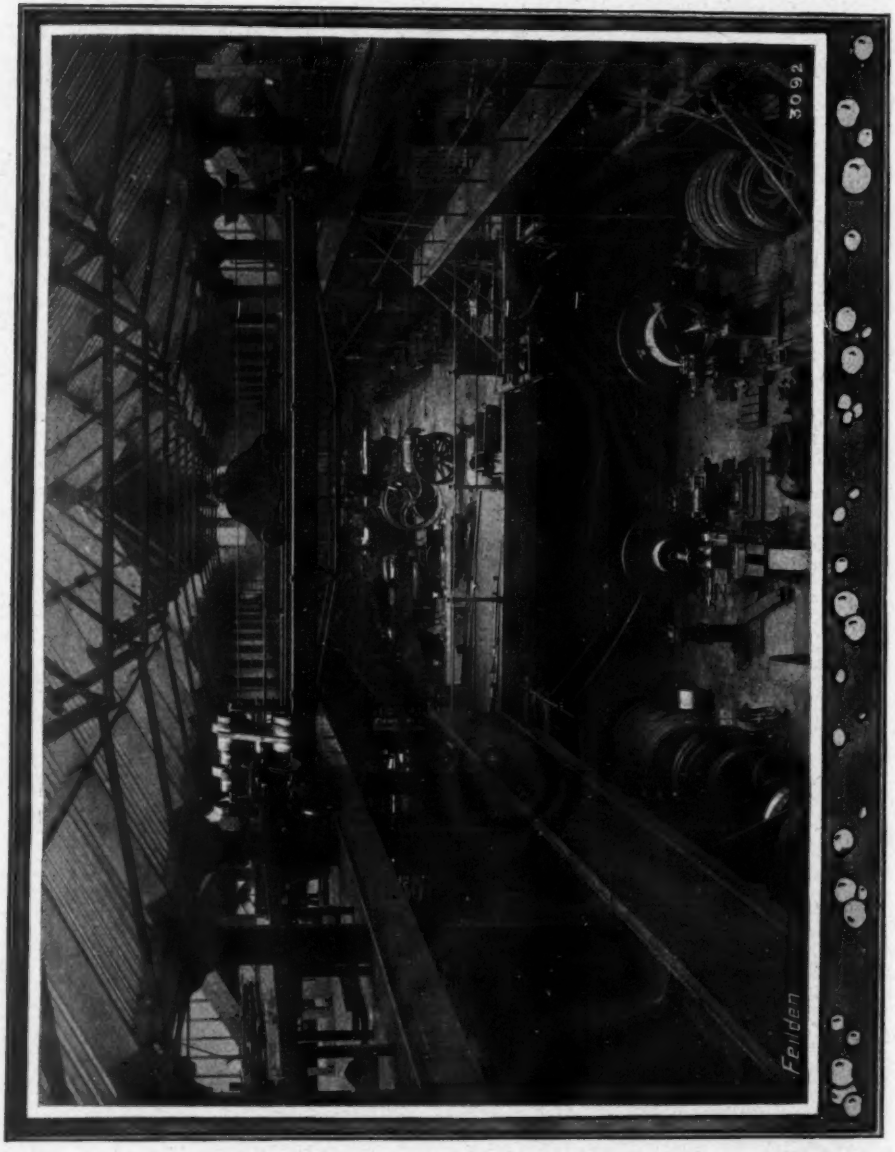
THE second establishment in this country to which we desire to direct the attention of our readers, in order to show them the manner in which the principle of specialisation is applied for expediting the execution of orders and reducing the cost of manufacture to the utmost limits, is that of Messrs. R. Cundall & Sons, Ltd., at Shipley, known as the Airedale Iron Works.

These works, when all the offices are completed, will cover an area of an acre and a half, while the shop area under roof will represent a floor-space of two acres. At present this area comprises one and a half acres with a half acre serving as yard room. The main bays are 290 ft. in length and 30 ft. wide, and the chief building contains four of them; the foundry has a width of 40 ft. In their present form many of the buildings date from 1900, replacing those erected in 1889, when the Airedale Iron Works were first inaugurated, and afterwards partially destroyed by fire. This conflagration was,



PLAN OF AIREDALE IRONWORKS, SHIPLEY.

1. Front Yard.
2. Riverside Yard.
3. Entrance to Iron Rack and Low Delivery Door.
4. Office Entrance and Enquiry Office.
5. Correspondents' Office.
6. Private Office.
7. Lavatory.
8. Waiting Room.
9. Cashier's Office.
10. Drawing Office.
11. Cellar Store.
11a. Cellar Store under Offices.
12. Store Room.
13. Cellar under Store Room.
14. Long Narrow Cellar.
15. Pattern Store Attic over Store Room.
16. Principal Pattern Stores over Engine Shop.
17. Stores on Basement alongside Boiler.
18. Area.
19. Small Cellar access to Steam Engine main Bearing.
20. Boiler House.
21. Right-hand Bay Top Shop (Folding-Machine Department).
22. Central Bay Top Shop (Folding-Machine Department).
23. Left-hand Bay Top Shop (Turning Department).
24. Room over Boiler House (Turning Department).
24a. Gallery over Steam Engine.
25. Right-hand Bay Fitting Gallery.
26. Left-hand Bay Fitting Gallery.
27. End Gallery used for Light Machines.
28. Pattern Makers Gallery.
29. End Pattern Makers Gallery.
30. Right-hand Bay Low Shop (Basement).
31. Right-hand Central Bay Shop "
32. Left-hand Central Bay Shop "
33. Left-hand Bay (Basement used for Planing Machines).
34. Old Foundry.
35. New Foundry.
36. Core Stove.
37. Gallery in Foundry.



AIREDALE IRONWORKS, SHIPLEY: ONE OF THE MAIN BAYS, SHOWING OVERHEAD TRAVELLER DRIVEN BY AN OIL ENGINE.

AIREDALE IRONWORKS, SHIPLEY: ONE OF THE MAIN BAYS, SHOWING OVERHEAD TRAVELLER DRIVEN BY AN OIL ENGINE.

AIREDALE IRONWORKS: MAIN BAY.

perhaps, not an unmixed evil, for after this baptism of fire this establishment has reappeared as one of the pioneer works, heralding a new era of British industry, being modelled, in part, after American examples, which having arisen under conditions less restricted than those prevailing in Europe, show a closer adaptation of means to ends than is to be seen in many types, where all existing forms of works bear traces, showing that the necessity of considering the existing limitations has interfered, and often disadvantageously interfered, with rational developments. That the adoption of the most progressive ideas from our transatlantic kinsmen has been a wise measure, is evident from the most superficial inspection, and it will suffice, in support of this statement, to mention that Messrs. Cundall are in the position to compete successfully as regards price, time of delivery, and quality, with our German rivals in their own country, though of course, German patriotism offers an obstacle to the enterprise of even the most efficient of foreign firms. The fact in itself, however, that a British firm, notwithstanding our belatedness, has succeeded in recovering the ground lost by our reprehensible indifference to the activity of our competitors in so short a time, and in finding a place in their front rank, is a sign in itself that our defeat in some lines of industry will soon be redeemed, and that *ceteris paribus, i.e.* under equal conditions and having equipped ourselves with the same modern appliances that our opponents use, we shall hope to soon restore our lost prestige, for in addition to all the modern devices which we shall have adopted from our competitors, we will have one advantage not to be secured by adoption or otherwise, *i.e.* a tenaciousness of purpose, a dogged persistence, growing stronger rather than being weakened where obstacles are to be met.

It is this undoubtedly that has aided this firm in grasping so swiftly the means of success that have aided hitherto their American rivals, and to use them to such excellent purpose.

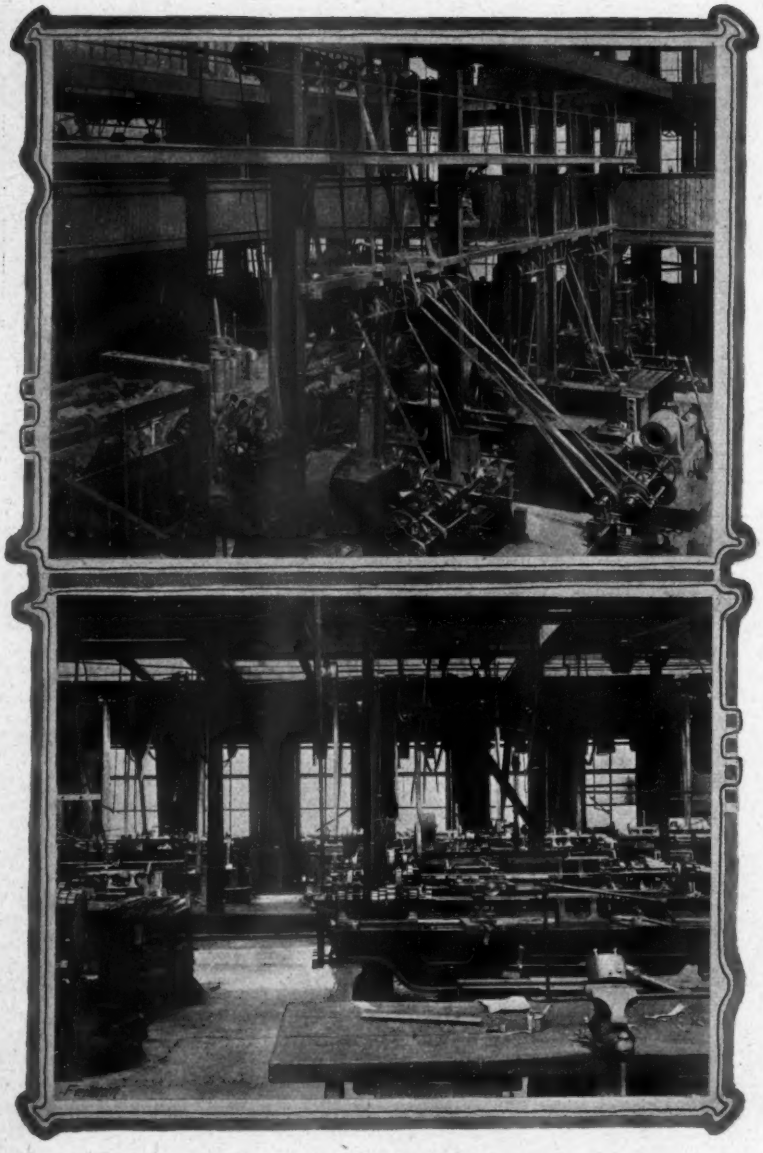
A mere glance at the "finished parts' stores" will instantly impress the visitor by the admirable thoroughness with which the work is performed, and for the time being produce the impression that a gulf of 3,200 miles has been bridged in a couple of years, and the best features of American methods have become firmly rooted in British soil. Everything in these stores progresses with the accuracy and regularity of clockwork.

The moment that a stock of given parts approaches exhaustion, the pattern store superintendent issues, on his own initiative, instructions to the foundry, and at the same time sends down the necessary patterns.

The castings over which particular care is exercised—so much so that pickling or sand-blasting operations are not resorted to—are distributed to the various machines performing the required operations, which take place in strict sequence and in such a manner that never has the same ground to be passed over again. When each part is finished, such of them as are to constitute a complete portion of an engine, are fitted in order to be ready for use at a moment's notice, and are then stored in numbered bins from which they are released when wanted by order of the storekeeper. The engine parts fitted and stored in the bins are of great variety, comprising vaporisers, valves, cranks, cylinders, governors, always in duplicates sufficient in number to fill even the biggest order without more delay than is required for placing them in position and uniting them into a complete machine of the type required. Usually there are stored in these premises about one hundred engine bodies and the component parts to complete them. The moment an order arrives and is accepted, the storekeeper receives instructions to deliver the engine body and bed to the fitting shop, and as soon as these are in place the loose parts arrive and are securely combined. Thus a minimum of time suffices to construct the complete engine, while weeks elapse in machine shops where the parts are moulded only after an order is received, and it is this arrangement which has heretofore secured to Americans nearly all orders where time was of importance, since until quite recently they alone have kept the completed portions of engines in stock so as to fit them when required. None of the engines, however, built by Messrs. R. Cundall & Sons, of however much importance time may be, leaves their shops without being thoroughly tested, and every one of them is so constructed as to give 20 per cent. above its nominal power.

Another important feature among the principles adopted in the Airedale Iron Works is that for each distinct shop there serves one, and one type of machine only, specially built to perform this job in the most thorough and expeditious manner. Machines with interchangeable parts, those iron "Jacks of all trades," are conspicuous by their absence. They, like their human prototypes, are well enough in a hamlet or some primitive settlement, but are no good in an up-to-date, thriving establishment, where mediocre work

A



B

AIREDALE IRONWORKS: VIEW OF THE MACHINE SHOPS.
A. OIL ENGINE DEPARTMENT. B. FOLDING-MACHINE DEPARTMENT.

A

B

[AIREDALE IRONWORKS

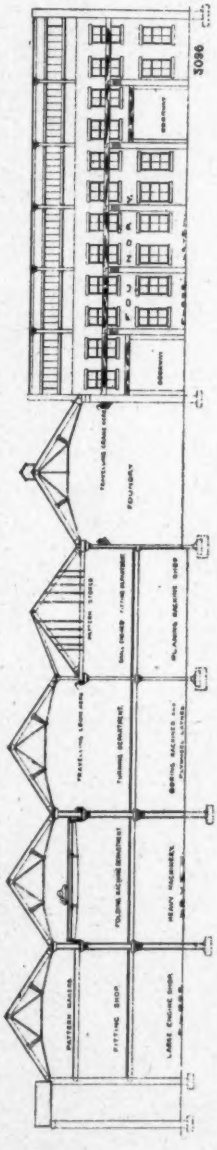
A. SPECIAL FLY-WHEEL LATHES. B. ENGINE BODIES READY FOR FITTING.

is useless, and the very best only will answer. The best possible work, of whatever kind it be, requires—as experience has shown—the whole attention of a man, and that skill which is the result of thorough familiarity with every phase and detail of his task derived from constant practice. Thus also, when an ingenious mechanism performs the most important portion of what in former times was entirely left in the hands of the skilful labourer, the best product is obtained from machinery, in which every single part, every screw, every spring, every wheel, is designed for one definite kind of task, and one only; and where nothing that is most suitable for the task as it is, is modified, nothing altered, nothing changed in the slightest degree, in order to make it suitable also for some other performance. Even the slightest alteration for the purpose of rendering the machine suitable for multifarious duties must necessarily be made at the expense of thorough suitability for one definite kind of work; and wherever the output is large, this slight compression between the best for one thing and "nearly" the best for several kinds of things becomes by multiplication a factor of sufficient importance to be taken into account. It has been taken into account by Messrs. Cundall, and this is not the least among the causes of the efficiency at their works. All their mechanical appliances are fully up-to-date, many of them are quite unique, and there is an abundance of power for the performance of all the work that is likely to be required during the day. The cutting speed on the large fly-wheel lathes, it may be mentioned incidentally, rises up to 40 ft. per minute. They weigh from 25 to 30 tons, stand on beds of concrete weighing over 40 tons., and are capable of taking wheels up to 12 ft. in diameter.

The special appliances are met with in almost every portion of the works. In the foundry special boxes are to be found for every separate type of engine, and constructed in such a manner as to obtain a high-class casting, with the least possible consumption of sand and the reduction of cost to a minimum; while in the machine shops there are ten different planing machines constructed to suit the various types of engines and beds. The boring of cylinders also is all done by specially designed tools, and so constructed that the cutting is done simultaneously at all the various points. Moreover, every process, once begun, is completed ere the piece of machinery dealt with is removed. For example, a cylinder is bored, a cylinder end faced and the crank bearing bored on one machine, and in one continuous operation. The fly-wheels are bored and faced, and each side of the boss and rim turned, at one and the same time by special lathes, all of which are self-feeding.

Crank-turning is performed by machinery operating four tools at the same time, which, in continuous operations, turn the web on both sides, the corners, and the shafts. There are three spindle drills, designed for three simultaneous operations. Among the cam-making machines must be mentioned a special type of profile milling machine for repeating the cam cutting, and there are turret lathes of great variety used for studs, valves, valve-spindles, etc.

The time saved by the above-mentioned precautions and arrangements is obviously considerable, and specialisation of production, combined with a most rational division of labour and a sequence of operations so that the same ground never has to be gone over twice, renders possible an easy victory over those competitors at home



ELEVATION OF THE AIREDALE IRONWORKS.

and abroad who still use the cumbersome methods of the past. While the latter have to move the material from place to place, backward and forward, so that it may pass through the required operations that can be performed only in definite localities of their shops, where each piece has to bide its time until earlier, but perhaps far less important, jobs are dealt with, in the Airedale Iron Works everything moves with the regularity of clockwork after a previously arranged programme, and no job interferes with any other, or, once begun, has to wait for completion until other jobs are finished. Taking as an example the operations through which a cylinder-head passes: directly after the casting, the planing or facing is done; then the marking off to dimensions from templates takes place, the joint is made on a specially designed machine for fitting the cylinder, and provided also with a device for boring the holes. Another contiguous machine does the tapping: then the fitters begin their work, valves are fixed, studs are inserted, the vaporiser placed in position, after which it is sent to the finished-part stores.

The whole of the machinery is driven by one main tandem-compound condensing engine of 400 h.p., to which steam is supplied from a Lancashire type boiler of 7 ft. 8 ins. diameter and a length of 29 ft. A "Green Economiser" assists in reducing the cost to the utmost. The circulation of the water for testing and other purposes is maintained by power-driven pumps whose action is rendered practically automatic by means of floats. A small independent oil engine is used for feed-water purposes, and could in case of emergency be used as a fire engine.

Messrs. R. Cundall & Sons, Ltd., was inaugurated 22 years ago at Thornton, near Bradford, by Mr. Robert Cundall and his four sons as printers' engineers, and their earliest specialty was a book-folding machine; performing with, what was then considered to be, marvellous rapidity work formerly done entirely by hand, and while hand-folding cost, say, from 1s. 8d. to 2s., machine-folding reduced this cost to 1¼d.

Up to 1883, Messrs. Cundall still used the cumbersome old methods for building their machines, but by that time their business had so increased as to render the original establishment inadequate for the work, and their works were removed to Commercial Street, Shipley, and obtained a lease for 5 years; all four sons of Mr. Robert Cundall, *i.e.* Messrs. J. S., R. D., W. D., and H. C. Cundall, had become under-partners. The present location was selected in 1887. In size, as well as in the management of the work, the Airedale Iron Works are the product of steady evolution and adaptation, and their owners try, not only to be abreast, but where possible, also to be a little ahead of the times. Thus, for instance, the latest form of their folding-machine appropriately bears the name of 20th Century engine. Their chief specialty at present, however, is their well-known patented oil-engine, the success achieved by which is due to the owners of the Airedale works in adopting, as above shown, all that is best in the methods of their transatlantic or continental rivals.

How Great Britain is meeting Foreign Competition.

Speaking of the restless enterprise of the Americans, Lord Rosebery recently remarked that in the New World the disdain of finality, the anxiety for improving the best, seemed almost a disease: but in Great Britain we could afford to catch the complaint, at any rate in a mitigated form, and give in exchange some of our own self-complacency. We needed to be inoculated with some of the nervous energy of the Americans.

Whilst endorsing Lord Rosebery's views, and largely sharing the opinions of other critics that our country has too long traded on its unique reputation, FEILDEN'S MAGAZINE deprecates anything which might tend to show that Great Britain is a decadent nation, and is not able to successfully compete with America or any other country. That the unprecedented progress which was made by this country in the past is not going to stultify the actions of our manufacturers is beginning to show itself pretty forcibly in the magnificent equipment of many new workshops throughout the United Kingdom; and whilst we shall continue to impress British firms with the necessity of constantly following the sage advice of Lord Rosebery, we cannot allow it to go forth that we have nothing but obsolete plants and ideas in this country. In a recent issue we started a series of articles, entitled "How Great Britain is Meeting Foreign Competition," and produced a profusely illustrated article written by an expert member of our staff, showing the up-to-date nature and completeness of a great North of England shop In this and succeeding issues we continue the series. The details should form object lessons of great value.

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

Setting Out Wheel Teeth.—Those who have had little or no experience in the setting out of wheel teeth are at times inclined to regard the operation as something very difficult, or look upon the necessary data as exclusive knowledge invested in a foreman or leading hand, from whom all information must be obtained. This, however, is being gradually swept away, and with the introduction of workshop-practice into the pages of engineering papers, knowledge and ideas are being diffused to the betterment of the artisan, and a general advance on the old systems of work.

In dealing with the subject of gearing, all theoretical matter has been left out, and only the necessary information and practical methods inserted that will ensure a proper understanding of the respective value of each form of tooth, and the different conditions under which they are used. In order to make the explanation as clear as possible, each detail is so defined that, after a perusal, no difficulty should present itself to anyone possessing some knowledge of arithmetic, and who is desirous of setting out the tooth form for any ordinary gearing.

The primary factor in all gears is the *pitch* or distance *from the centre of one tooth to the centre of the next*, and when we speak of a wheel of so many teeth of such a pitch, we assume the given number of teeth to be set on a straight line, and equi-distant from each other.

To convert this straight line into a circle, the circumference of which shall equal the length of the line, we multiply the length by ·31831, the sum of which is equal to the pitch circle, and contains the given number of teeth of the required pitch, measured as indicated by the dotted lines at Fig. 1. Having defined the pitch of a wheel, and before proceeding further, some little explanation is required, as some conflict of opinion has taken place among recognised authorities as to which is the more correct, the arc pitch or the chord pitch; but the latter, from long experience, has been generally adopted as being more practical and involving less calculation, the measurement of the arc being too abstruse for workshop practice, and the variation between it and the chord too slight, only in exceptional cases, to affect the

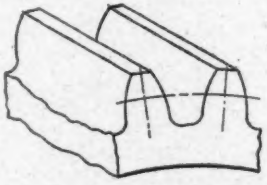


FIG. 1.

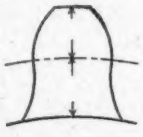


FIG. 2.

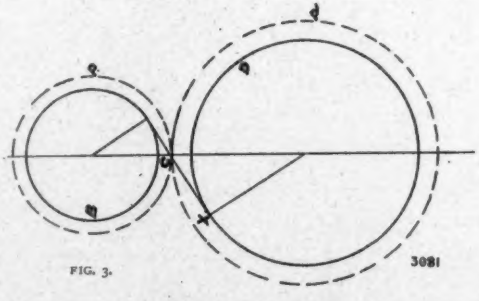


FIG. 3.

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SETTING OUT WHEEL TEETH.

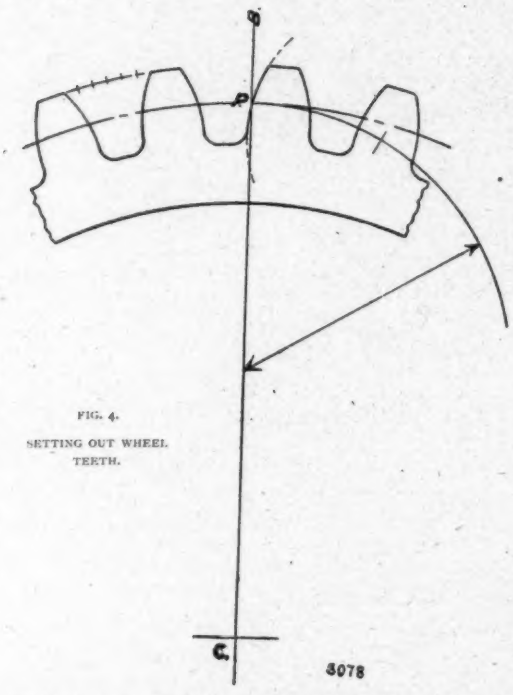


FIG. 4.
SETTING OUT WHEEL TEETH.

working. An example, in which the variation is most conspicuous, is that of a wheel or pinion of comparatively few teeth and coarse pitch.

The correct diameter of the pitch circle is then obtained by the following rule. Divide the number of degrees in a circle by twice the number of teeth in the wheel, then divide the pitch by twice the sine of the quotient. The answer equals the radius of the pitch circle.

The following example of a pinion 15 T, 4 in. pitch, illustrates the rule :—

$$\frac{360}{30} = 12. \quad \text{Sin } 12^\circ = \cdot 20791 \times 2 = \cdot 41582$$

$$\frac{\text{pitch}}{\cdot 41582} = 9 \cdot 61 \text{ Radius of pinion.}$$

The term "diametral pitch" is applied to wheels having a given diameter, and containing a certain number of teeth. These do not fall into the ordinary fractional measurements, hence they are sometimes termed "broken pitches;" still, it must be admitted that this form of pitch is fast superseding the circular pitch in modern practice on gears of small diameter.

Numerical pitches are named and calculated as follows. A wheel of 32 T of 8-in. diameter would be 4 pitch, similarly one of the same diameter, but containing 48 T, would be 6 pitch. In finding the diameters for wheels of this kind, the number of teeth required is divided by the numerical pitch, the quotient gives the diameter.

The *overall diameter* is found by the addition of two more teeth to the required number before the division is made; for example, a wheel of 60 T, 5 pitch, would be supplemented by two teeth, and $\frac{62}{5} = 12\frac{2}{5}$ ins. the overall diameter.

Similarly, a wheel of 2 pitch with 47 T, would have an overall diameter of $24\frac{1}{2}$ ins., the height of tooth above the diametral pitch line being the fraction of an inch equal to the numerical pitch.

The several forms of teeth are known as the involute or single curve, the epicycloid or double curve and the Odontograph tooth, each of which possesses a special advantage briefly described as follows. The single curve tooth is usually employed in the finer gears, being seldom used in wheels above $1\frac{1}{2}$ in. pitch. The special feature of this form of tooth is, its smooth working, whether it be deep or shallow in gear, hence its adoption where positive distance of centres are not always convenient, as change-gear on lathes, wheel-cutting machines, or other dividing mechanism.

The epicycloidal or double curve is the form generally employed in heavy gearing where strength is required and where centres can be fixed, the primary condition of correct working being the relative position of the teeth when in contact; they *must* be correctly geared on the pitch-line, so that the teeth surfaces have a sliding motion when rotating. This particular form of tooth admits of no departure from the pitch line, any deviation at once destroying the theoretical effectiveness of the gear.

The third form of tooth, viz.—the Odontograph, is frequently used in place of the previous one, it being a simplified method, whereby the approximate curves forming the sides of the tooth can at once be determined from a scale. A slight difference is apparent in this to that of the preceding form, the root of the tooth being more spread, whilst the tips are more rounded off, thus they are admirably suited to gearing liable to

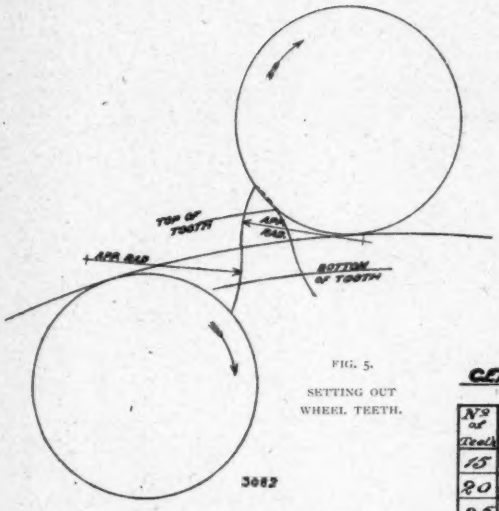


FIG. 5.
SETTING OUT WHEEL TEETH.

sudden shocks, as cranes and other hoisting gear.

In regard to the height of tooth, there is nothing arbitrary, though in modern practice a much shorter one prevails than formerly, the several dimensions as given at Fig. 2 being those adopted for ordinary work, longer and shorter ones being used under special conditions.

It must be understood that whatever form of tooth is decided on, the height makes no difference, as the curves forming the sides are merely continued from the pitch line to the top and bottom of the tooth. The involute, or single curve, is formed by the releasing of a flexible strip of steel from the periphery of a disc, to which one end is fastened, the diameter of the disc being less than the pitch circle of the wheel.

At Fig. 3 is shown a method whereby the correct curve is described. Let *P P* represent the pitch circles of a pair of wheels, and with a radius equal to diameter at bottom of tooth describe base circle *B*, draw a tangent to base circle *B*, cutting point *C*. Describe a circle *D*, touching line at *X*, move point *C* round towards *B*, describing curve for face of tooth on *B*. Move *C* round towards *D* for face of tooth on *D*, thus forming correct curves for working faces of both wheels.

As the striking out of a series of teeth by this method would become rather a tedious operation, it is usual to set out the curve for one side of a tooth only on each wheel, and by means of dividers find an approximate radius.

A circle described with a radius equal to the distance from the centre of the wheel to arc centre, provides a line for the centres of the arcs forming the sides of the teeth. A modification of this method for describing involute teeth with satisfactory results is shown at Fig. 4.

Having described the pitch circle of the wheel, draw a line *B C* from centre touching pitch circle, and with a radius equal to one-fourth the *diameter* of the wheel, describe a semi-circle on line *B C*. From the point *P*, where the line *B C* touches the pitch circle, with

CENTRES FOR ROOTS OF TEETH.
Pitch in inches.

No. of Teeth	1	1¼	1½	1¾	2	2½	3
15	19	62	74	86	99	123	148
20	25	31	37	43	49	62	74
25	19	24	28	33	39	48	57
30	17	21	25	29	33	41	49
40	15	18	21	25	28	35	42
50							
60	13	15	19	22	25	31	37
70	13	16	18	21	24	30	36
80	12	17	18	20	23	29	35
100	11	14	17	19	22	28	

CENTRES FOR TIPS.

15	5	7	8	10	11	14	17
20	6	8	9	11	12	15	18
25	"	"	"	"	"	"	"
30	7	9	10	12	14	16	21
40	8	10	11	13	15	19	23
50	"	"	"	"	"	"	"
60	9	10	12	14	16	20	25
70	"	"	"	"	"	"	"
80	9	11	13	15	17	21	26
100	"	"	"	"	"	"	"

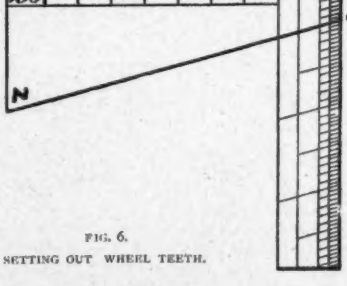


FIG. 6.
SETTING OUT WHEEL TEETH.

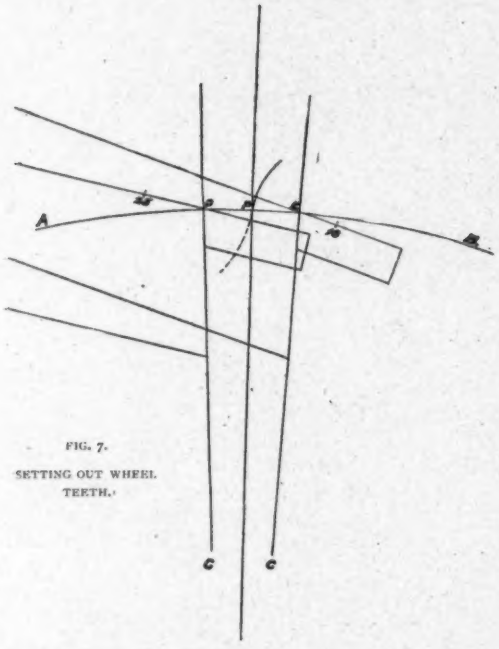


FIG. 7.

SETTING OUT WHEEL TEETH.

dividers set to one-fourth the radius of the pitch circle, cut the line of semi-circle. This new point may be continued by describing a circle with a radius equal to the distance from this point to the centre *C*, which is called the base circle. Upon this line are located the centres for the arcs, forming the sides of the teeth, each arc being struck with the radius used for locating the point on the semi-circle. The tooth form is then strengthened with a hollow or fillet equal to *one-sixth* of the space between the teeth at the tips, as marked to the left of Fig. 4. By this method a good form of tooth is described, and the trouble of preparing the discs and steel connection avoided. The base circle may be at once determined by multiplying the pitch circle by the constant ·968; thus a wheel of 10-in. diameter on the pitch circle would have a base circle 9·68 ins., and from this line would be struck the arcs, forming the tooth sides with a radius of $1\frac{1}{4}$ ins.

The epicycloidal or double curve tooth is formed by rolling a disc of thin timber, of proportionate diameter, on the inside edge of a concave templet for the bottom curve of the tooth, and by a similar operation on the outer edge of a convex templet in order to describe the curve for the tip of the tooth. The radius of both templets being that of the pitch circle and the diameter of the rolling disc or generating circle equal to 2·2 of the pitch, so that a wheel of 2-in. pitch would have a rolling circle 4·4 ins. diameter on the periphery of which is usually glued a small piece of pencil to form the marking point which traces the curve as shown at Fig. 5. The teeth for a series of wheels may have the whole of the curves traced by the *same* rolling disc, but on separate templets, which coincide with the radii of the pitch-circles, and all of which will gear correctly. As in the generated curve for the cycloidal tooth, approximate arcs are found, with which to draw the tooth form on each wheel.

The Odontograph, Fig. 6, an invention to facilitate the setting out of wheel teeth, may be made from a thin piece of hard wood, or preferably from a piece of sheet brass, and its method of application is shown at Fig. 7. The first position for locating the centre for the root arc, and the second for that of the tip arc. By reference to Fig. 6, it will be seen that the edge of the instrument is graduated on one edge, each division being the $\frac{1}{20}$ of an inch.

A line *YZ*, drawn at an angle of 75 degs. across the plate, is called zero, the divisions to the left hand being used for the roots of teeth, and those to the right hand for the tips. To simplify the setting, a portion of the plate is cut away from zero to the right, as shown. Parallel lines enclose the tabular numbers assigned to number of teeth and pitch of wheel required. The method of procedure is as follows:—

Assume a wheel of 60 T. 2-in. P. Then, with a radius equal to that of the pitch circle, describe an arc *A B*; from a point *P* set off *P D P E* equal to halfthe pitch; from centre *C* draw lines through *D E*. Place the line marked *O* on the radial line *D C*, and at the twenty-fifth division to the left coincident with tabular number mark a point, remove instrument, and with dividers set to distance from this point to *P*, describe arc for root of tooth. With *O* on radial line *E C*, and with the edge touching point *P* on arc *A B*, mark point for centre of arc for tip of tooth corresponding to number 16, as per table. From this point to *P* as a radius, describe arc for tip, thus completing one side of tooth.

Similarly the opposite sides are marked off, the location of the centres being continued as concentric circles from which all arcs are struck. As in the preceding method all wheels set out on this principle, gear correctly with any others of the same pitch. In regard to thickness of tooth some little judgment is required, as the amount of clearance given in a wheel of 1 in. pitch would be altogether too much for a wheel of 6 ins. pitch if followed out proportionately.

Thus far we have dealt with the ordinary form of tooth as applied to spur wheels, leaving the details of bevel, helical and other gearing to be treated in another article.

(Prize.) FOREMAN PATTERN MAKER.

Boring Holes to an Accurate Pitch.—In engineering practice it is often found necessary to bore two or more holes at a *very* accurate distance apart. A great deal of time and care is often spent in trying to do this, both on the drilling machine and in the lathe, the principal factors relied on being accurate setting out and careful working to the lines thus obtained. The following method obviates the necessity of such careful preliminary marking out, does not rely on scribed lines, and has been found in practice to give very good results with a minimum of time and trouble. Suppose the job to be operated on is a rectangular block of steel 6 ins. by 3 ins. by 1 in., in which it is required to produce two holes on the centre line 1 in. diameter and 2½ ins. apart. Mark off the centre of one hole as carefully as is found necessary, and make there a small centre dot; place the block on the face-plate of a lathe, bring up the centre till it just holds the block in position, then clamp it down to the plate. The first hole may now be bored and finished to size by means of a boring tool. Next clamp a straight strip of metal *B* alongside the block *A*. A distance-piece *C* must now be put at the end of the block; the length of this should be exactly equal to the pitch of the holes. *D* is a stop which is held up to the distance-piece and fixed firmly to the face-plate. The clamps on *A* are next slacked off, the distance-piece removed, and the block moved up to the stop *D*. The job is now clamped down again, care being taken that it beds nicely on *B* and *D* and the other hole bored. Further refinement may be obtained by using two distance-pieces (shown on the right of Fig. 1), one of which is longer than the other by a length equal to the pitch of the holes. The sense of touch will now show when the block is properly located. Or, again, an inside micrometer (Fig. 2) may with great advantage be used in place of solid distance-pieces. First measure the distance between block and stop, then subtract the pitch distance and move block till micrometer gives right reading. If the job to be operated upon is small, and the holes to be bored not in the same straight line, a square auxiliary plate *A*, as shown at Fig. 4, may be used with great advantage. Studs, as Fig. 3, are inserted in the face-plate at convenient distances from which to take measurements.

H. HELFRITSCH.

Attachment for Turning "Barrel Tapers."—The handy attachment here described can be applied to any existing lathe having an

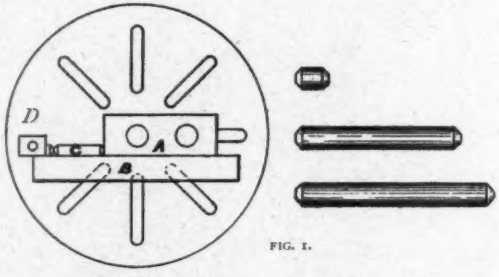
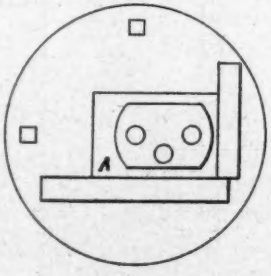


FIG. 1.

FIG. 2.



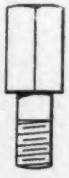


FIG. 3.

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FIG. 4.

BORING HOLES TO AN ACCURATE PITCH.

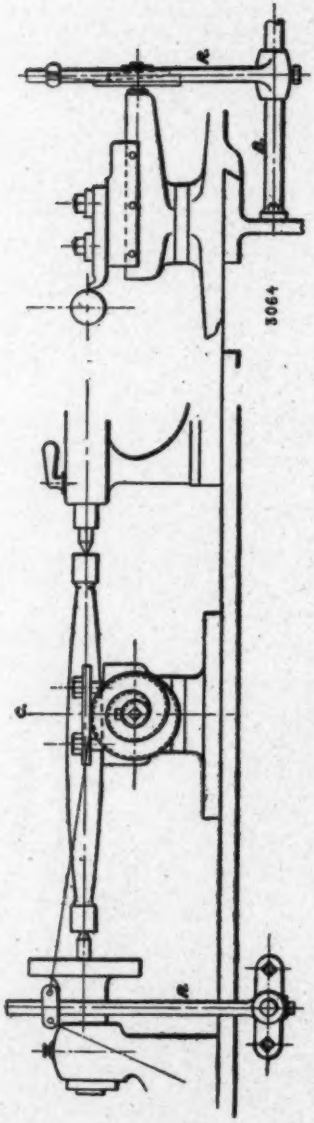

FIG. 2.

FIG. 1.

ATTACHMENT FOR TURNING BARREL TAPERS.

ordinary compound slide rest, and is a thoroughly reliable contrivance for shaping large connecting-rods, etc., of varying diameters. The rods, as most readers know, are largest in diameter at the centre, tapering towards both ends to a smaller diameter. These tapers not being straight lines, are commonly known as "barrel tapers," the extreme diameters being connected by a radial line, and as the rods have to be highly polished, they require to be a first-class job, without the ridges or variations sometimes seen on hand-finished work. The arrangement for producing this form is very simple, and will be easily understood by reference to Figs. 1 and 2, showing front and end elevations. A vertical rod *R* is fixed on a bar *B* terminating in a foot, which is fixed to the side of the lathe-bed, an ordinary ratchet drill fixing serving the purpose. To the rod *R* a length of weight-chain is attached by a collar and set screw, and to prevent any tendency to dragging over, the chain is carried beyond the upright and the end fastened to the lathe-bed. In order to produce the convex line on the rod a cast-iron scroll is made, from 8 to 12 ins. diameter, of four or five convolutions, and with a square hole in the centre to fit the end of the screw, moving the top slide of the compound rest. Previous to starting the chain is wound round the periphery of the scroll, beginning on the large diameter. The cut on the rod is taken from the centre *C*, and by traversing the carriage towards the loose headstock the chain gradually unwinds, giving an increasing traverse to the top slide, and producing the required contour automatically, consequent upon the quickened advance of the slide screw as the diameter of the scroll becomes smaller.

J. GREEN.

[It would be necessary to make the ratio of the scroll proportionate to the extreme diameters and length of the rod.—ED.]

To Machinists, Fitters, Foundrymen, Foremen, Shift Engineers, &c.

To afford you an opportunity of bringing your practical ideas and experience into print is the purport of the WORKSHOP PRACTICE SECTION of this magazine.

Most of you have had some experience of breakdowns, emergency devices, or jobs bringing into play your inventive capacity. Such experience is valuable and is worth recording.

Send us the facts, accompanied by sketches, and we will do all that is necessary to render them fit for publication.

ONE GUINEA

will be awarded for what is, in the opinion of the editor, the best contribution of the month, the remainder being paid for at our regular rates.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

Direct-Reading Photometer. — Dr. Emile Bose, of Breslau, has recently made the very interesting discovery that if between two gold electrodes immersed in a slightly acid solution an electric current has been passing for some time, one of the electrodes becomes covered with a thin layer of hydroxide. Upon stopping the electrolysing current and connecting the electrodes through a high-resistance galvanometer, a deflection is obtained when light is made to fall on the electrode covered with the hydroxide stratum; and since the intensity of the current varies with that of the light falling on the electrodes, the discovery promises to bring us nearer towards the construction of a direct-reading photometer.

Northern Manchurian Railway.—At this year's anniversary of the Czar's coronation the news arrived that the laying of the rails of the North Manchurian railway was completed, and that within a few months this connection between Vladivostock with the Trans-Siberian railway will be open to traffic. Hitherto it was necessary for travellers to Vladivostock, when leaving the Siberian line, to proceed by steamer on the Amur to Khabarovsk, which is connected by rail with that place. Once that the line above-named has come into use, however, there will be no break between Moscow and the eastern terminus, except the passage across the lake Baikal; and it will require several years yet ere the line round the southern end of the lake, which will be begun immediately, is completed. It may be mentioned also that a line which connects Port Arthur with a station on the Manchurian railway is already open to traffic.

Specialisation in the United States. — In connection with our article on specialisation and its growth in the United Kingdom, commenced in the last issue of FEILDEN'S MAGAZINE, it may interest our readers to learn how one of the consequences of extensive specialisation in engineering, such as exists in the United States—namely the growing dearth of general mechanics—is being met by the owners of the famous Baldwin Locomotive Works. The remedy devised is a modification of the apprenticeship system, so as to secure a supply of foremen, assistant foremen, and other subalterns. For this purpose apprentices engaged are divided into three classes, says one of our contemporaries. The first class consists of boys 17 years of age, having had a good common-school education, who will bind themselves for four years, and during that period submit to the supervision of their conduct by the firm both inside and outside of the workshops. These apprentices will be obliged to attend during the first three years of their course night classes, in which they will be instructed in elementary algebra, geometry, and mechanical drawing. The second class consists of apprentices who, before being accepted, must show that they have had an advanced grammar- or high-school education. Their term of apprenticeship is to be three years, and, unless already fair draughtsmen, will have to attend night classes in drawing. The third class consists of young men of the age of 21 years, who are graduates of technical schools desiring instruction in practical shop-work and are ready to sign an agreement for two years All apprentices will not only have a chance of learning their trade, but their general welfare will be watched over, and care will be taken that their work is changed as soon as their proficiency renders such a change expedient; and an official called the Superintendent of Apprentices will see to their general comfort and good behaviour.

Petroleum as Disincrustant.—A useful hint regarding the employment of coal-oil for disincrusting boilers is given in our contemporary *La Mercure Scientifique*, by M. Marcel Guedras. He points out that it should not be used with boilers already coated with scale if external firing is used, for where a layer of deposits exists already the mineral oil penetrates its pores, reaching the plate, and, under the influence of continuous heat, the lighter portions are volatilised, while the heavier, during the progress of decomposition, swell, detaching the scale from the plate. In the case of external firing, since the carbonaceous deposit thus formed tends to rest on the hottest plates, overheating may result; in internally fired boilers, even if scale already exists before introducing the petroleum, this danger is not present. As regards the disincrusting process by means of petroleum as such, the oil—which is easily introduced with the feed through a sight-feed displacement lubricator, such as ordinarily used for cylinder lubrication—forms an emulsion inside the boiler which prevents the agglomeration of the particles of lime, and, instead of their forming a hard deposit, they remain in the condition of a soft mud, easily washed out.

"Broken" Joints.—The roadsmaster of the Chicago, Burlington and Quincy Railway, Mr. F. J. Allen, states that several years of experience with tracks laid with "broken" joints as well as with "square" joints has convinced him that the former are in every regard superior to the latter. The chief advantage is that when "broken" joints are used the general condition of the road is better, and it is much easier and far less expensive to keep the track, especially where curves exist, in good order.

Invasion of our Colonies.—That American manufacturers do not only invade the Mother Country, but attack the outposts of the British Empire with the same vigour and are using the same tactics that they employ here, may be seen from the following circular sent to us by a correspondent in Queensland, to whom it was addressed from New York:—"A syndicate of leading independent American manufacturers of electrical apparatus and supplies has been formed for the purpose of arranging for the sale for export of their manufactures through a central corporate organisation. The lines represented in this syndicate are non-conflicting and completely cover the requirements of the installation and supplying of electric lighting and power plants. It is the purpose of the managing corporation of this syndicate to appoint in each of the electrical trade centres of Europe and other countries an agency, in the care of an individual, a firm or corporation, and to grant to that agency such territorial jurisdiction as it may be able to properly control. Agents must have some knowledge of the science of electricity, be familiar with electrical machinery, instruments, etc., show unquestionable credentials as to character, trade standing and selling ability, be fully acquainted with the *personnel* of the trade in the district requested, and have sufficient capital to carry accounts. The syndicate will cover such a complete line that agents must in business be confined solely to the interests of the managing corporation. An officer of the managing corporation will be in Europe in the course of a few weeks for the purpose of meeting applicants for agencies and closing arrangements. A letter addressed to the writer by return mail in this regard, stating in detail what facilities you or your friends have to offer, would receive due attention, and, if it appears desirable, an appointment for a personal meeting here or in Europe could be made."

Unusual Installation of a Propeller Shaft.—We take the facts given below from an article in *Marine Engineering* on the subject referred to by Commander H. Webster, U.S.N., who justly thinks the incident described worthy of attention. The torpedo-boat *Shubrick*, built by the William R. Trigg Company, of Richmond, Va., had been waiting in vain for its propeller shafts, and the time had arrived for clearing the ways to make room for other work. Not being allowed to remain longer in its position, the vessel had to be launched in its incomplete condition. As the shafts were not to be ready before March of the present year, and the launching took place in October, 1899, the problem was whether it would be possible to instal them where the vessel lay, or whether the long trip to the nearest dry dock at Norfolk, and the great expense of docking, would have to be incurred. After some reflection the builders decided to avoid the great cost and to risk trying a novel method of fitting the propeller shafts. For this purpose, when the shafts arrived, the vessel was raised out of the water a sufficient height to permit the installation to be carried on from floats alongside and under the vessel, and, to the delight of all concerned, the method employed turned out to be a complete success. No more mechanism had been employed than would have been required in hoisting any other body of similar weight, as is shown in the photographs accompanying the description in our contemporary. The only detail not visible to the eye is the fact that the bow of the *Shubrick* was depressed by the admission of about 22 tons of fresh water into the forward compartment, facilitating the emersion of the stern and adding lateral stability during the suspension. The water, it is true, was smooth at the time the work was going on, but, of course, the success of the somewhat daring enterprise was due to a large extent to the excellence of the hull-work and the skill of the men supervising the work, as the vessel suspended had an extreme length of 175 ft., while the distance of the point of emergence to the perpendicular stern line amounted to 62½ ft. in somewhat more than one-third of the total length. A careful examination failed to show that any undue strain had been imposed on framing or plating, and the ease with which the shafts were placed was in itself a proof that no deformation had taken place. Under these circumstances the builders may be well congratulated on their deserved success both as regards the work done and the cost incurred, for the latter amounted only, including wages and the use of a derrick for 17 hours, to 232 dols. 82 cents, which is a saving of 767 dols. 18 cents when compared with the estimated expenditure of 1,000 dols. that would have been incurred for docking and towing.

Train Resistance.—The problem of train resistance was recently dealt with in a paper read by Mr. Aspinall, President of the Institution of Civil Engineers, who commented on the results of experiments carried out with a dynamometer car on the Lancashire and Yorkshire Railway, and undertaken with the object of ascertaining the effort required to haul modern railway carriages. The author said that the most important factor in the resistance to be encountered by a moving train was wind-pressure, and this factor had heretofore not been sufficiently inquired into. After having described various instruments and devices for determining the direction and velocity of the wind, he pointed out that the equipment of the car was such as to permit of two separate diagrams being taken. One diagram recorded—(1) Tractive effort, (2) thrusting effort, (3) speed in miles per hour, (4) velocity of the wind, (5) time of application of brake, (6) time occupied in minutes, (7) distance travelled, and (8) points at which indicator-diagrams were taken. The second diagram was arranged

to show—(1) Tractive effort, (2) thrusting effort, (3) speed in miles per hour, (4) revolutions of car-wheels, and (5) time occupied on journey. He showed how rigid coupling of the engine with the experimental car was accomplished, and how the draw-bar springs were tested. Modern bogie-carriages, fitted with oil axle-boxes, had been used for the experiments, and their number constantly varied, the results obtained in each case being recorded. The method of testing had been the following: "The position of the regulator and reversing-gear on the engine was marked for each trial, these positions being governed by the speed at which it was desired to run. After the regulator and wheel had been set they were left in position during the whole of the run, the engine being allowed to acquire whatever speed it could, and steam-pressure being kept as constant as possible. Both the outward and return journeys were made with the engine set in exactly the same position. This was judged to be the best method of ascertaining the tractive force required to haul the train at different speeds, as the acceleration which would have been caused by altering the position of the regulator was entirely eliminated; and the gradients being very slight, it was possible to obtain readings at a constant speed for a mile or more." There were some apparent discrepancies in the results of some of the tests, for which the author suggested causes, but the general result is expressed in the following formula:

$$R = 2{\cdot}5 + \frac{V^{\frac{2}{3}}}{50{\cdot}8 + 0{\cdot}0278\,L},$$

where R was the resistance in lbs. per ton, V the velocity of the train in miles per hour, and L the length of the train, over coach-bodies, in feet. Numerous "coasting" experiments with trains of different lengths, with and without engine, had also been made, and the results were recorded in diagrams. In conclusion the author emphasised the fact that, valuable though this formula is, its applicability is restricted to the particular trains tried under the circumstances described only, the ever-varying nature of the conditions of running in practice rendering it practically impossible to find a formula of general applicability.

German Sheet-Iron for Export.—According to the *Rh. Westph. Zeitung*, the rumour that the great sheet-iron combine in Germany is actively engaged in organising an export association is fully confirmed. The first move of this association will be the systematised export of ship and boiler plates to Scandinavia, Holland, Belgium, and Great Britain; and, after the export of these articles has been placed on a firm footing, stout iron sheets for a variety of other purposes will be pushed in the foreign markets. The important feature in this export trade is that all exports will pass through the offices of the combine, and that the latter will regulate the prices.

The Great American Steel Trust.—According to recent information, subscribers of the famous Steel Trust had 12½ per cent. of their subscriptions returned to them. Owing to their successful operations, it seems, the Trust no longer requires the money, to raise which the last issue was made. It is also announced that the underwriting syndicate will transfer 25,000,000 dollars' worth of the Trust stock in individual accounts. The aggregate profits of the great Trust for the month of October are reported to have been 11,500,000 dols.

The "Armorl" Electro-Capillary Relay.—This relay, said to be sensitive to $\frac{1}{300}$ volt, is based on the same principle as the capillary electrometer—viz. the action of an electric current on a liquid contained in a capillary tube. The apparatus consists of an inverted U-tube containing mercury. One end of this tube is immersed in a mercury reservoir, and the other end, which is drawn to a fine point, reducing the bore to something in the order of 0·004 in., dips in a bath of dilute acid. Just beneath this point is one end of a lever, whose middle rests on a knife-edge, the other end of the lever moving between the two contacts of the local circuit. The height of the mercury in the reservoir is such that its pressure is just balanced by the capillary at the point of the tube. The current is led in at the top of the bend of the U-tube and out at the bath of dilute acid. As soon as a small current passes, the capillary force is diminished, and the mercury begins to drop from the tube, ceasing again as soon as the current ceases. The mercury falling on the end of the lever tips it up and closes the local circuit. This relay, we are informed, is the joint invention of Messrs. Axel Orling and J. T. Armstrong, but no opinion can as yet be expressed as to the utility and reliability of the apparatus, which must be largely dependent on the mechanical details of its construction.

The Great Californian Power Transmission Scheme.—The preliminary work for the gigantic power transmission scheme by which 50,000 h.p. are to be transmitted from the San Joaquin River to San Francisco, a distance of 180 miles, is progressing. The main drainage area affected is 1,000 square miles. The power-house is situated 21 miles from the intake on the river. Forty-four 8-ft. to 9-ft. tunnels, through solid granite, will have to be cut, showing that the work to be done is worthy of the daring enterprise. The fall allowed will be 7½ ft. per mile, while the reservoir will be 1½ mile by 250 ft. The water, instead of through pipes, will be carried from a point on the mountain down to the power-house, 1,730 ft. below, through an inclined tunnel.

Contracts for Cape Railways.—It is satisfactory that, at all events, some of the rumours regarding government contracts placed abroad are without foundation. Thus Reuter's correspondent at Cape Town announces that the Cape Railway Commissioner has received a cable message from Sir Charles Elliott, stating that his total purchases and orders for the Cape Railways placed in America did not exceed £600. The approximate value of the rolling-stock ordered in the two

past years is £1,050,000, of which amount the orders placed with British firms represented about £900,000. The orders for railway stores from July, 1900, to September, 1901, amounted in value to £905,906, of which Great Britain supplied £899,657. An order for rails for a light line was placed on the Continent at £4 13*s.* 9*d.* per ton, while the lowest British tender was £6 4*s.* 4*d.* Trucks to the value of £2,630 have been obtained from Hungary at about half the price of the lowest British tender. The Agent-General is authorised to give British firms a preference of 10 per cent., but British firms must be prepared to meet the requirements of prompt delivery at reasonable prices. The news that nine-tenths of the orders for supplying material for the Cape Railways have come to British firms in spite of the fact that the American quotations were frequently lower is certainly very satisfactory, especially since patriotism alone can hardly have been a sufficient cause in every instance, and superior British workmanship will form probably the true reason in the vast majority of cases.

Bristol Docks.—According to our contemporary the *Contract Journal*, the Docks Committee at a recent meeting authorised the engineer (1) to purchase a new dredger for use in the upper parts of the floating harbour and the feeder canal; (2) to repair the pump at St. Vincent's Spring; (3) to carry out further repairs to the locomotive "Harold"; (4) to grant Messrs. Elder, Dempster & Co. a site at Avonmouth Dock upon which to erect workshops, on terms to be arranged; (5) to accept the tender of Messrs. D. Y. Stewart & Co. for hydraulic pressure pipes for the cranes at the new wharf in the East Mud Dock. The engineer also submitted plans for the provision of immediate temporary accommodation for the storage of grain, and he was instructed to proceed with the repairs of the back sheds at Portishead.

The Returning Tide.—Though we still see many big orders carried away from our shores towards the ocean and to our near relations living on the other side of it, the lowest water-mark in the ebbing current of our industrial prosperity has, let us hope, very nearly been reached, and ere long the tide must turn. Even now the eddy brings some welcome, though as yet isolated, signs of the approaching change. Thus, to give one instance merely, though the order for the great lifts for the South London Railway was given to an English firm, *i.e.* to Easton's, that for the Central London Railway lifts went to New York. Meanwhile sufficient time has elapsed to study both the British and American types of lifts and their respective defects and advantages. What has been the result of such an examination may perhaps be deduced from the fact that the order for those for the Great Northern and City Railway has just been awarded to British makers. Still, in order that our manufacturing and exporting firms may not think that the danger is entirely over, and that no extra efforts are required, we may just as well give them a little list of facts that are not exactly of the kind to make them prophesy prematurely their ultimate victory. The Crystal Palace authorities had need of some motor-cars with a seating capacity of ten. Of course, to make even an effort to get them here would have been sheer waste of time, so the President proceeds to the United States to ask for tenders, and may be sure to obtain exactly what is wanted with the least possible delay. An opportunity for people living in one of our Colonies to get in the Mother Country a well-equipped electrical plant did not exist until quite recently; what more natural, therefore, than that the directors of the Sydney (N.S.W.) Tramway Company should look towards the same country for the equipment of their generating station which is to supply the motors for the Crystal Palace authorities, and they found what they asked for. A Milwaukee firm has sent out the engines required, while the total equipment, at an expenditure of £160,000, is being prepared in America for shipment to Sydney. The British Westinghouse Company in itself is a constant reminder of our backwardness, but to emphasise the fact this British company of American origin is obliged to send across the Atlantic and to place at Bridgeport, Con., U.S.A., a contract of the value of £35,000, for machine-tools required for their new Manchester works. Other instances might be added, but these will suffice to show that, even though a reaction has began, our energy required to retrieve the past must be kept at high tension.

An American Diaphragm Cell.—In a recent issue of the *Electrician*, Mr. John B. C. Kershaw describes a diaphragm cell for the electrolytic production of alkalies and chlorine which, it is claimed, contains many advantages. Mr. Kershaw, however, remarks that it so closely resembles the Hargreaves-Bird type of cell that even if it should turn out to be a commercial success, a suit to establish priority of invention is almost certain to follow. The patentees are Messrs. Moore, Allen, Ridlen and Quincy, all of America. For a fuller description we must refer our readers to the English patent No. 4,269 of 1900. The main advantages claimed for the Moore-Allen cell, are said to be that no steam is required to remove the sodium or potassium hydrate from the cathode, that a fairly concentrated solution is obtained from it which contains but a small quantity of undecomposed salt, and that as an enclosed cathode department is dispensed with the construction of the cell is considerably simplified. A glass dome for the chlorine exit of the cell renders it possible to observe the process from the outside, and to lessen the dangers arising from electrical short circuits by the lead of chloride collecting pipes. Mr. Kershaw doubts whether it is possible to produce a solution of caustic alkali containing but little chloride at the cathode in the way described in the patent, and therefore thinks the cell is defective in an essential point, even granting the other improvements to be as stated.

In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

With few exceptions copies of the articles referred to in this section can be supplied by us. Price 1s. 4d.

ARCHITECTURE AND BUILDING.

1. Construction and Design.

Standard Sections.—*Standard Sections in Iron and Steel Structures.* Extracts from the Presidential Address of Mr. Charles Hawkesley, read before the Institution of Civil Engineers on Nov. 5, 1901, in which the important subject above mentioned is referred to. Mr. Hawkesley draws attention to the fact that British engineers, no doubt often suffered inconvenience and their clients loss, owing to the absence of standardisation of iron and steel. In this country an engineer, when designing a roof or bridge, selects from the book of some well-known firm the section of angle and tee iron best suited to his requirements, and, after one of the tenders has been accepted, the contract is let. Presently, however, the contractor returns, and asks permission to substitute another section for one of those selected, as the latter is no longer in stock, and the makers are not inclined to reproduce it. In America and Germany, in order to avoid such emergencies, standard sections of iron and steel have been adopted, with great advantage to all concerned. Within the near future Great Britain will have followed suit. Prof. Hawkesley, with regard to this matter, stated that the Council of the Institution of Civil Engineers, realising the necessity of adopting standard sections if English manufacturers are to compete on equal terms with foreign manufacturers, some time ago approached the Institution of Mechanical Engineers, the Institution of Naval Architects, and the Iron and Steel Institute with a view of taking up the subject, and an influential committee was appointed, consisting of members taken from each of these institutions, to inquire into the matter. This committee having taken evidence as to the desirability of standardising iron and steel sections from representatives of the various industries interested in the matter in this country, as well as from those representing the Colonies, the opinion in favour of it, as the committee's report shows, was so unanimous in favour that the Council of the Institute of Civil Engineers decided to accept the committee's recommendation, and to proceed with the work of fixing the standards at once, the labour being distributed between four sub-committees, which are at present engaged to determine the standards most suitable for (1) Bridges and General Construction, (2) Railway rolling stock and trains, (3) Rails, and (4) Ships. Mr. Hawkesley, in conclusion, expressed the hope that after the first step in the right direction others will follow, and that the system of standardisation may soon be extended also to other engineering requirements.—*Builder*, Nov. 9th, 1901, p. 715.

CIVIL ENGINEERING.

1. Bridges and Viaducts.

Bridge Design.—*Excessive Refinement in Bridge Design.* In an editorial on the above subject the author points out that probably the most striking feature in the earliest bridge designed by American engineers was the extreme individualisation or differentiation of members. The stresses in members were absolutely defined, and treated as single forces; in fact, the extreme limit of articulation was not only aimed at but practically attained. These early processes, he proved, signified great refinement in design, and constituted a field of structural operations of a high degree of excellence. With the gradual extension of high-speed railway traffic, however, it was found that rapidly moving trains shook the flexible bridge structures into vibrations that threatened in some cases to be disastrous. It became clearly evident that greater rigidity had become imperative, and that it had to be secured by giving joints, especially lateral joints, the greatest possible stiffness. Every advance in bridge design has in modern times been accompanied by a further increase of stiffening, and in many cases has consisted in nothing but the creation of details calculated to secure this increase. This holds true especially as regards the rigid rivet connection between railroad bridge floor beams and columns, which, as the author remarks, is one of the most admirable features of modern American bridges. He further expresses the opinion that practice in the United States has demonstrated conclusively that the so-called "secondary stresses" need in no way be regarded as an objection in any degree to properly designed rigid connections, and concludes with a pointed criticism of the double-track railway bridge across the Rhine at Worms, Germany, which was completed in November, 1900. In the design of this bridge, which totally differs from modern American bridges, scrupulous care is taken to avoid all those features of structural stiffness just mentioned, and which the author had shown to be recognised in the United States as so essential to meet the demands of the heaviest railway traffic at high speeds. Between the 383-foot spans there is no transverse bracing, and not a stiff connection either between floor beams and their supports or between the upper lateral system and the upper chords. The construction, in fact, according to the author, is such as to incite the most active, not to say violent, lateral and vertical vibrations under high-speed trains. And all this sacrifice of some of the most essentially excellent qualities in modern bridge construction he declares to have been made for the purpose of avoiding secondary stresses, found chiefly in the result of computations based largely on conditions that do not exist. The rigid portals, according to the author, constitute the only saving features of the structures; for in them are concentrated the vibrative effects of the entire span, though only after the body of the bridge has perhaps been injuriously shaken.—*Engineering Record*, Oct. 26th, 1901, p. 392.

Bridge Renewal.—*A Railway Bridge Renewal.* Under the above heading is published a description of the solution of an interesting problem, namely, that of reconstructing a bridge at the place of intersection of two railway lines without interfering with the traffic on either line. The bridge was the property of the company owning the line underneath the bridge, and was, there-

fore, burdened with the onus of repairing and renewing the structure. The track running over the bridge, however, was that of a line of greater importance, as regards through and constant traffic, and it was of the utmost importance that this traffic should suffer no delay. The writer of the article shows how the work was carried on for more than four months without causing on this important line any more damage than the delay of one train—a Sunday train—for 20 minutes. The trains of the company owning the bridge, however, were very seriously delayed, and a rather serious accident occurred—though, fortunately, without loss of life—owing to the fact that during the last period of the work the double line had to be changed into a single line.—*Engineer*, Nov. 15th, 1901, p. 514. (Ill.)

Concrete Arches.—*New Concrete Arch Bridges at Niagara.* By Orlin E. Dunlop. Description of two new bridges of the kind above named, built on the New York State Observation at Niagara Falls, to connect the mainland with Goat Island. They were recently completed, and are conspicuous by their attractive appearance, which means a good deal in a neighbourhood by no means poor in pleasing structures. One of them extends from the mainland across the upper rapids to Green Island, while the other, the shorter of the two, joins Green Island to Goat Island. These bridges were begun in the summer of 1900, and although the contractors, Messrs. W. H. Keepers & Co., of New York, made strenuous efforts to complete them last year before the winter set in they found the task impossible. The article contains many interesting references to structural details, and is accompanied by three illustrations, one giving a view of the bridge from the mainland to Green Island after completion; the second shows the bridge in course of construction, the steel ribs being open to view, so that the way in which the concrete is laid can be seen; while the third shows the timber false-work. — *Scientific American*, Nov. 23rd, 1901, p. 327.

Railway Bridges.—*The Rankin Bridge.*' The article contains a rather full description of a double-track railway bridge, on the main line and hot-metal track of the Union Railroad across the Monongahela River at Rankin, Pa., U.S.A., near the famous Homestead Steel Works, and a mile-and-a-half below the Port Perry crossing of the same line, designed and constructed under the direction of Mr. W. H. Smith, chief engineer of the Union Railroad, Mr. E. K. Morse being the consulting engineer for the substructure, while the superstructure was built and erected by the American Bridge Company, of which Mr. C. C. Schneider is the chief engineer. The article gives a full account of the basis of the designs and all the essential structural details of the bridge, which has a total length of 2,211 ft., crosses the river channel with two main spans, 500 ft. and 252 ft. long, on centres of piers, and has plate-girder approach viaducts on both shores. Its chief peculiarity is its massive construction, rendered necessary for the very heavy loading specified, which produced a weight of about 5,000 tons for the superstructure. Equally interesting is the special design of the river end of the south approach, where the crossing and diverging of the tracks in the Y-shaped junction resulted in an elaborate arrangement of heavy plate girders, forming a triangular platform about 80 ft. wide and 120 ft. long, supported over the river with three masonry piers.—*Engineering Record*, Nov. 16th, 1901, pp. 465-71. (Ill.)

River Regulation.—*Modern Methods of River Regulation.* By Ignatius Pollak, Engineer of the Imperial Provincial Government of Lower Austria. Under this heading is reproduced a lecture delivered by Mr. Pollak to the Railroad Section of the Society of Austrian Engineers, in which he gives a very interesting exposition of the views of two famous authorities on hydrotechnics—namely, M. H. Girardou, Chief-Engineer of the Department for Roads and Bridges, specially appointed for works connected with the River Rhone, and M. V. de Timonoff, Professor at the Technical Institute for Road-building at St. Petersburg—regarding river regulation. He prefaces his remarks by pointing out that Girardou was the first to break with the old traditions predominating in this kind of work, and aimed at the preservation of the peculiar character of the river, trying to prevent the regulating work from interfering with it, except where absolutely necessary, and to avoid giving to it the appearance of a canal. Speaking of Timonoff, Mr. Pollak remarked that as regards this point the Russian engineer was in full accord with his French colleague, though he differed greatly from him as regards the means of securing this object.—*Zeitschrift des Oesterreichen und Ingenieur Architekter Vereins*, Oct. 4th, 1901, pp. 654-8, and Oct. 11th, pp. 671-5. (Ill.)

ELECTRICAL ENGINEERING.

1. Theory.

Electrons.—*The Development of the Electron Idea.* By W. Kaufmann. Under this heading a translation is published of the author's lecture delivered on the occasion of the 73rd Congress of German Natural Scientists and Physicians, held at Hamburgh, and published in the *Physikalische Zeitschrift* of October 1st, 1901. The author points out that it is not an unusual phenomenon in the history of science that views considered obsolete and out of date for some time suddenly, though in a somewhat modified form, come into favour again. An extremely interesting case of this kind, he continues, is presented by the revolution in our ideas of electrical phenomena which has taken place within the last ten years. The bulk of the lecture is practically an attempt to show that the modern theory of electrical and applied optical phenomena, which he summarises as the "electron theory," is in its essential features but a return to views laid down in the sixties and seventies by Wilhelm Weber and Zöllner, though modified by the results of the researches of Maxwell and Hertz. — *Elektrician*, Nov. 8th, 1901, pp. 95-97.

—— *The Electron Idea.* This is the heading of an editorial summarising and commenting on Professor Kaufmann's lecture above referred to. The author of the editorial, though obviously appreciating the contents of this highly interesting contribution to the theory of electrical science, appears to think it necessary to defend its publication in the *Electrician* by refuting the anticipated criticism that the subject has no "practical' interest—a truly serious charge in our era of commercialism.—*Electrician*, Nov. 8th, 1901, pp. 94, 95.

2. Electro-Chemistry and Metallurgy.

Electrical Industries.—*Electro-Chemical and Electro-Metallurgical Industry.* By John B. C. Kershaw. Under this heading the author deals with the subject in two articles; the first refers to the progress and the condition of the industry in the United States, while the second deals with the United Kingdom. In the first we are informed that the United States' output of raw copper in 1900 amounted to 268,000 tons. The number of electrolytic refineries in that country is eight, with an aggregate capacity of 211,000 tons per year. The aluminium production during the same year amounted to 3,190 tons, 10,000 h.p. being reserved for its manufacture at Niagara. There is good reason to hope that by the end of the present year 7,700 h.p., derived from water-power, will be devoted in the United States for alkali and chloride manufacture. Short references are made in conclusion to the manufacture of calcium carbide, the chlorates of potash and soda, and nickel. In the second article Mr. Kershaw deals with chemical and metallurgical industry in the United Kingdom. He points out that, although industrial electro-chemistry may be said to have had its beginning in this country, it has developed far more rapidly elsewhere, and England in fact, as far as the importance of its electro-chemical works and their output is concerned, ranks fourth or fifth only among modern nations. As regards copper refining for instance, it was James Elkington who, in the year 1865, patented the electrolytic method, and it was first put into operation in 1868 at Pembrey, South Wales. Later, the new process was adopted in other places, and in 1886 there were four refineries in the United Kingdom, the largest of them being that of Messrs. T. Bolton & Son, at Froghall, in Staffordshire. This refinery and another belonging to the same firm at Widnes are the most important ones at present in the United Kingdom, where there is plant for the refining of between 20,000 and 30,000 tons of electrolytic copper. Since, however, refineries have been started in the United States, the American pyretic ores, which, owing to their great richness in gold and silver, are best adapted for the electrolytic refining process, are no longer shipped to Europe, which, in fact, at present supplies the American refineries with ores. The result is, that for the time being not only the British but also the other European refineries have more or less of their plant idle.

Passing over to the electrolytic production of aluminium in Great Britain, which dates from 1886, in which year the Cowles aluminium factory was started at Milton, in Staffordshire. In 1896, says the author, the Heroult process was introduced into the country by the British Aluminium Company, who adopted it at their works at Foyers, in Scotland, which since then have been gradually expanded, so that now 14,000 h.p. are available for industrial purposes, an electrical generating plant of 5,000 h.p. having been installed. The Castner mercury process and the Hargreaves-Bird process are being used for the electrolytic production of alkali and chlorine, but a gravity process has, as Mr. Kershaw points out, proved a failure. The conclusion of the article is devoted to short references regarding the electrolytic manufacture of calcium carbide, sodium, the peroxide of sodium, the extraction of zinc from its ores, and to zinc plating.—*Electrical Review* (New York), Oct. 12th and 26th, 1901, pp. 511-14.

3. Measuring Instruments and Methods.

Electrical Indicator.—*Callendar's Portable Indicator for Platinum Thermometer.* The article contains a description of a portable bridge for reading Professor Callendar's platinum thermometers. These thermometers, originally intended for laboratory use, have, as the author of the description says, been found extremely serviceable in more than one industry. They consist essentially of a fine wire wound on a mica core, and protected against noxious gases by an envelope of glass or porcelain, the former material being used when low temperatures are to be determined, while the porcelain is the best covering when high ones are to be measured. The principle underlying the measurement is that the electrical resistance of such a coil varies with the temperature, so that by measuring these variations of resistance by means of a Wheatstone bridge the corresponding temperature can be ascertained with great accuracy. Various types of bridge have been used for this purpose, and the portable kind referred to in this contribution have recently been constructed and placed upon the market by the Cambridge Scientific Instrument Company, of Cambridge. This bridge consists of a combination of a set of resistances and a galvanometer of the d'Arsonval type. The instrument is graduated in such a manner that the temperatures can be read off direct from the scales of the apparatus in degrees, Fahrenheit or Centigrade, the range of temperatures that can be measured varying in some of the instruments from 0 deg. Cent. to 1,400 deg. Cent.—*Engineering*, Nov. 8th, 1901, p. 644. (Ill.)

4. Dynamos, Motors, and Accessories.

5. Electric Transmission of Power.

Water-Power Plants.—*Shawinigan Water-Power Development.* Description of a Canadian water-power plant situated at Shawinigan Falls, Quebec. This plant was started for working on the 19th of October last to furnish for the first time current to the Pittsburg Reduction Company. This power-house, 77 ft. by 74 ft., with a height of 34 ft. up to the eaves, contains two water-wheels of 3,000 h.p. each, while to each of them are connected two direct-current 300-volt. generators of 1,000 k.w. capacity each. Among other clients of the new power-plant will be, it seems, the Belgo-Canadian Pulp Company, which has erected a pulp mill in the neighbourhood, and will be supplied with water from the Shawinigan Water and Power Company by means of a development separate and distinct from the electrical undertaking.—*Western Electrician*, Nov. 2nd, p. 285. (Ill.)

6. Electric Lighting and Heating.

Electric Burners.—*Electric Burner for Blast-Furnaces.* This is an abstract of a paper by F. L. Grammer, read before the American Institute of Mining Engineers. The author prefaces his remarks by stating that in re-starting an abandoned plant with untrained labour, and in running big 100-ft. furnaces, slips, resulting in very cold furnaces, may occur, even under experienced managers. He then relates that such misfortune did once happen during his own superintendence, owing to the death of a trustworthy foreman. On that occasion his electrician, Mr. Thomas Martin, he says, proposed to him to open the tuyères and cinder-notch, which were frozen in, by means of the heat of the electric arc. Although the idea was entirely new to him, he gave his assent to the experiment. He then describes how this was carried out, from failure at first to absolute success in the end, and states that when their success became known the method was used by several other persons in an equally satisfactory way. In conclusion, he recommends making a permanent installation for such emergencies in blast-furnaces, since such a remedy as the one tried is often badly needed.—*Engineering and Mining Magazine*, Nov. 9th, 1901, p. 607.

7. Telegraphy and Telephony.

Type-Printing Telegraph.—*The Murray Type-Printing Telegraph.* Under the above heading is reproduced a detailed technical description of the instrument referred to, taken from a paper read by Mr. W. B. Vansize before the American Institute of Electrical Engineers. The characteristic operations for obtaining the desired result with the Murray printing telegraph are as follows:—The messages are first transcribed on a type-writer which, instead of printing upon, perforates the tape. The latter is then made to pass through a transmitter, similar in design to Wheatstone's, and thus the messages are transmitted to the receiving-station, when they re-appear again as perforations on a tape. The latter is introduced into a type-writer, the keys of which are controlled by the perforations, and by operating the type-writer mechanically the message is printed on the ordinary message form in Roman characters. There is an outline of the *modus operandi*, to which the article here referred to adds all the essential details of the construction of the various parts, and of the share they have in the work. Reproductions of two photographic views and several diagrams give assistance to the reader.—*Electrician*, Nov. 8th, 1901, pp. 86-90.

8. Materials and Methods for Conducting Currents.

Aluminium.—*Aluminium as a Substitute for Copper.* Under this heading an editorial writer comments on the fact that we hear so frequently the assertion that the use of aluminium will gradually supersede that of copper in all electrical undertakings. He points out that very frequently the assertion is made by persons who know very little of what they are talking, though from time to time there have been electricians ready to endorse the assertion. It is true, he says, that aluminium can be, and has been, used for conducting purposes in power plants, and for the transmission of power from such plants. Of its use for the former purpose recent installations at Niagara, and in some localities in California, furnish abundant testimony, and experts have affirmed that by its use for this object good results were obtained. Regarding the use of aluminium for transmission wires, there seems to be still some doubt as to whether, in a northern climate, the wires will stand the stresses of snow, ice, and high winds as well as copper does. But, says the editorial writer referred to, granting that aluminium could be used to a large extent as an efficient substitute for copper in electrical work, perhaps the most important point, apparently ignored by many advocates of the change, is whether the supply will be sufficient to meet the demand. He then quotes figures that seem to show that a sufficient supply certainly does not exist at present, and gives reasons why it is not likely that it will exist in the future. Thus he shows that in 1900 the total production of aluminium in the world was 5,570 metric tons, of which the United States furnished 2,050 tons, while that of copper was 792,625 metric tons, of which the United States supplied 272,536. This means that the total output of aluminium last year was only 1·1 per cent. that of copper. "Until these figures are greatly changed," he adds, the competition of aluminium is not likely to affect the copper market. Of course, aluminium being a manufactured article, the supply is ruled by the demand; but the question is, to what extent can the production be increased." The fact that the present production is so small, notwithstanding that the best metallurgical skill has been concentrated on the problem, is not a very encouraging sign for a very great increase in the near future.—*Engineering and Mining Journal*, November 9th, p. 594.

Wiring.—*Wiring Rules.* By C. H. Wordingham. M.Inst.C.E. The author points out that we ought to

discriminate between "wiring" rules and "supply" rules. He deprecates the idea that it is possible to draw up wiring rules that will cover every conceivable case, saying, "one might just as well attempt to draw up rules by which a central station could be erected." He suggests that something similar to the corporation certificates which he introduced into Manchester might advantageously be adopted for the registration of electrical fittings of all kinds, and be inaugurated under the auspices of some central authority—if possible, the Institution of Electrical Engineers.—*Electrician*, Nov. 8th, 1901, pp. 84-5.

9. Electric Traction.

Electrical Railroad System.—*The System of the New Orleans and Carrollton Railroad Company.* The article published under the above heading contains a very full description of an electric street railway system distinguished by thorough and efficient organization and by many peculiar features due to local conditions and careful adaptation to these conditions. Among the distinguishing characteristics of the attractive city of New Orleans is the fact that many streets contain in their centre a strip of ground covered with turf. This is called neutral ground, and is excellently suited for laying street railway tracks, since the grass-covered soil is allowed to rise nearly to the top of the rails, and consequently the passing cars raise no dust. The New Orleans and Carrollton Railroad to which the article refers, owns about 33 miles of track and 100 cars. The track on the neutral ground, constituting a belt line on St. Charles Avenue, Carrollton Avenue and Tulane Avenue, comprising about 14 miles all-in-all, is laid with A.S.C.E. road section T rail, weighing 100 lbs. per yard. Part of this road is open as on a steam-road, but the greater part has, as above said, the raised turf-covered ground on either side, and it is safe to say that there is no road-bed elsewhere in the United States so agreeable to ride on as that of the New Orleans and Carrollton belt line, for aside from its being dust-free, the stiff specially selected rail gives smoothness and the sod deadens sound and prevents dirt from being carried on to the track. The company keeps a careful record of the "life" of all parts of the track and road-bed as well as of all the cars. The condition of the latter is judged, other things being equal, by the mileage run, and when a car has run from 15,000 to 20,000 miles it is considered necessary to supply new armature bearings and to carefully overhaul the whole equipment. Other parts of the plant are watched over with equal care and all important incidents concerning them are entered into their record, by which it is judged whether and when they are to be thoroughly inspected for the purpose of repairing or reconstruction. The main car house and repair shops are at Poplar Street. The main storage shed is a galvanized iron structure, contains ten tracks and a capacity of 80 of the company's standard cars. The "pit shop" adjoining is also a galvanized iron building 82 ft. by 212 ft., and contains seven tracks, three of these elevated for a distance of 80 ft. These elevated tracks take the place of the "pits" of the usual repair shops. This alteration has been found necessary owing to the fact that the ground in New Orleans is so wet—much of the city being below the high-water level of the Mississippi, which is confined by the "levées"—that great difficulty has been experienced in keeping pits free from water. Moreover, the elevated tracks have been found very convenient for removing and replacing wheels. The cleaning of motors, registers and controllers is accomplished by means of compressed air, which is also used for removing dirt and scale from trucks that are to be repainted, and for cleaning and sweeping the floor. Very interesting also is the system of fixing the payment of the employees, and the careful cost keeping. With reference to the latter, it may be mentioned that the cost per kilo-watt hour of the company varied last year from 7.7 millo to 9.2 millo.—*Street Railway Journal*, Nov. 1901, pp. 393-401. (Ill.)

Storage Batteries.—*Storage Batteries and 60-Cycle Railway Rotaries.* By Edward L. Reynolds. Under this heading the author describes a plant in Hamilton, Ontario, which comprises storage batteries in connection with 60-cycle synchronous converters. The power used for driving the plant is obtained from a waterfall 34 miles distant, and sent down in form of a current at a voltage of 22,000 volts to the sub-station, equipped with three 300-kilo-watt converters with transformers and the storage battery, to be reduced in voltage as required. The battery being operated in parallel with the direct-current side of the converter enables the latter to run steadily, and renders it possible to run the incandescent lights and the railway cars from the same bus-bars.—*Street Railway Journal*, Nov. 1901, pp. 402-4. (Ill.).

10. Miscellaneous.

Manufacturing Methods.—*Manufacturing for Stock.* This is the heading of a leader on the subject, in which the author arrives at the conclusion, as many have done before him, that if British manufacturers of electrical plant wish to compete with American and continental manufacturers, they must, to some extent at least, adopt their methods, one of which is to keep on stock "standard" machines and parts of machines. Up to the present many British manufacturers "are accustomed to passing orders into the shops and, except in the case of smaller machines, of requisitioning the raw material from the suppliers only on receipt of the order." In other words, even when using standard sizes and patterns, the machines are only turned out in quantities sufficient to supply what has been ordered, and only after an order has been received. This, the writer thinks, must change. It is a mistake, according to him, to say that if the demand requires delivery from stock the supply will come forth. Even if the demand for the moment does not actually render it necessary, as long as foreign competitors think it wise to execute their orders from stock, manufacturers in this country, if they wish successfully to compete, must, he says, do likewise. The demand for electrical machinery is increasing so rapidly, that the financial risk involved is no longer serious. "Quick deliveries," the writer remarks, in conclusion, "are becoming imperatively necessary, and it is to be hoped that the manufacturing capacity of this country will respond to the gradual change in the market requirements."—*Electrical Review*, Nov. 8th, 1901, pp. 737-8.

Standardisation.—*The Standardisation of Electrical Apparatus.* By J. T. Brodrick. In this interesting contribution the author supplements a previous article, dealing with standardisation from the manufacturer's point of view, by treating the subject with reference to the interests of the consumer. He shows that the steady progress of standardisation in recent years has resulted in lowering the price of all standardised supplies, has ensured prompt delivery, and has considerably contributed to the reliability of the article supplied and the efficiency of electrical installations. To this must be added also the advantage of a reduction in the cost of repairs due to the interchangeability of parts permitting their speedy renewal from stock kept. Mr. Brodrick gives due credit to the American Institute of Electrical Engineers and the American Society of Mechanical Engineers for their share in promoting standardisation. Finally, he gives buyers the sound advice to consult the manufacturer of standardised articles,—even when not wishing to supplant older types of apparatus by newer types, they merely desire to repair their plant, which is to ocostly to scrap it; for it is quite possible that some standardised article may be found suitable, or, without much difficulty, may be rendered suitable, and its introduction into the existing plant may considerably improve its efficiency. Standardisation, far from being an obstacle to progress, is, according to Mr. Brodrick, an aid to it, for "its purpose may be said to be," he concludes, "to reduce the ratio of cost to results secured. It is, therefore, in complete harmony with the present tendencies throughout the industrial world."—*Engineering Magazine*, November 1901, pp. 177-84.

Train Recorder.—*Automatic Train Recorder of the Brooklyn Rapid Transit Company.* The recorder here described can be seen in the office of the general manager of the Brooklyn Rapid Transit Company, and automatically registers, producing a permanent record, the train-movement on the elevated lines. It consists of a circular sheet of paper which is ruled in concentric circles at equal distances from each other, these circles being intersected by radial lines dividing them into twelve larger spaces of equal length representing hours, and sub-divided into twelve smaller spaces, also of equal length to each other, representing intervals of five minutes each. This circular sheet rotates by clockwork around its own centre, completing a whole revolution every twelve hours. Facing the sheet are several needles operated by electro-magnets, each of them from a dif-

ferent section of the elevated lines. At each of these points, however, the passing of which by a train is to be recorded, an insulated section of rail, 30 ft. in length, is installed. By means of an appropriate device, the cars when passing this insulated portion are made to energise the magnets operating the needles, and the latter punch a hole in the record sheet, or imprint a dot on it. In this way the manager, by looking at the automatic recorder, can at any time ascertain the position of any train and its frequency on any division of his lines.—*Street Railway Journal*, Nov. 1901, p. 406. (Ill.)

Turntables.—*Operating Turntables by Power.* This is an abstract of the report of a committee of the Association of Railway Superintendents of Bridges and Buildings, presented at Atlanta, Georgia, U.S.A., Oct. 16th, 1901, in which the operation of turntables by electricity, steam, and gasoline engines is compared. After giving a concise description of the various systems, the authors point out that the selection of the power to be used, and the apparatus to be employed, depend upon local considerations, such as, for instance, the greater accessibility for operating the tables in question to any special source of power as compared with any other source. If, however, electric power is readily obtainable, either from the railroad company's plant or from some other source, says the report, it should certainly be used, since it requires but little apparatus and is more economical than any other power. As a necessary precaution, however, inquiry should be made whether a suitable current is available at all times, including nights and Sundays. The report also contains a number of data both as regards first cost of plant and operating expenses. —*Western Electrician*, Oct. 26, 1901, pp. 271, 272.

MARINE AND NAVAL ENGINEERING.

1. War Vessels.

Armoured Cruisers.—*H.M. Armoured Cruiser "King Alfred."* Description of the above-named cruiser, launched on the 28th of October last from the Naval Construction Works of Messrs. Vickers, Sons, & Maxim, Ltd., at Barrow-in-Furness. The *King Alfred* is one of four vessels now building for the Navy. Outwardly these vessels resemble the *Powerful* and *Terrible*, the apparent difference being that their masts are not furnished with military tops, and that the poop has been cut away to increase the weight available for armour and guns. In reality, however, the similarity is deceptive, for great changes have been made in them, and they are practically without equals in the fleet. Thus, for instance, the speed has been increased to 23 knots, and there are four more 6-in. quick-firing guns, but as each individual gun is of greater power and attains a higher rate of fire the weight of projectiles which may be discharged per minute has been increased from about 6½ tons in the *Powerful* to about 9 tons in the *King Alfred*, while the muzzle energy has been more than doubled. While the *Powerful* was a protective-deck cruiser, with casemates for her 6-in. quick-firing guns, and similar protection for the bow and stern 9·2-in. guns, in the *King Alfred* the armour protection is most effective. The main and auxiliary machinery, as well as the boilers and the magazines, are protected by a waterline belt 11 ft. 6 ins. deep, extending over half the vessel's length and varying in thickness from 6 ins. amidships to 4 ins. at the ends. These and other striking modifications to be met with in this new type of cruiser are carefully stated in the article, and a photographic illustration showing the vessel just before being ready for launching adds considerably to the interest of the contribution.—*Engineering*, Nov. 1st, 1901, pp. 611-612. (Ill.)

2. Freight and Passenger Vessels.

Coal Vessels.—*The Ohio River Coal Fleets.* By H. C. Fithian. The above is the title of an article, both entertaining and instructive, on the transportation of coal down the Ohio River, which is the highway by which the coal of the western slope of the Alleghany Mountains is distributed throughout the West and South. This traffic is of a magnitude little realised abroad, and the methods employed for handling the coal have many features of interest well worth the attention of all who are interested in American industries. The author describes the two classes of boats used in the transport, the one called by the "river men" "coal boat" and the other "coal barge." The former is about 170 ft. long over all, with 28 ft. beam and 8½ ft. depth at the gunwales, and will contain an average of 25,000 bushels of coal. They differ considerably from the barge, and are built of much lighter material although they carry a greater bulk. Below the water-line they are made of 1½-in. material, while from the top to the water-line a strip, called a "drift streak," is worked of about 3 ins. thickness. They are fitted with what are called "check posts," five or six in number, round in shape and made from tree-trunks from 18 ins. to 24 ins. in diameter. They are set away from the sides and ends of the boat, and heavily braced with sapling wood from 3½ ins. to 4 ins. in diameter. While all these posts are called check posts, those that are one-fourth to one-third the length from the end are especially designated as the swing posts, and are so made and placed that in case of a heavy strain on the timber, from either wind or wave, enough to break an ordinary timber, the post would be pulled out of the boat, doing it no damage; whereas a similar strain on a timber head would pull the whole side out of the barge. The barges are, according to Mr. Fithian 135 ft. with 26 ft. beam, and 8 ft. deep, drawing 6 ft. to 6½ ft., carrying from 14,000 to 18,000 bushels each according to the state of the water. The barge is about 7 ins. thick on the sides, and 2½ ins. on the bottom. The author goes into a detailed description of this kind of river conveyance also, and then deals with the transportation of the loaded boats, mentioning among other facts that the towing boats or steamers usually handle from 12 to 16 "pieces," as both coal boats are called, *i.e.* an average of 14, with an aggregate load of 350,000 bushels, and as there are about 125 tow-boats engaged in the business, of which about three-fourths are classed as "large boats," the total amount of a "run" would represent many million bushels. The largest tow on record leaving Pittsburg was brought down, it appears, by the steamer *Joe B. Williams* in the spring of 1900 with 30 "pieces," ten more being picked up at Cincinnati for Louisville, while the largest single run of coal was made in the autumn of the same year, when about 60 steamboats came out with a total of some 17,000,000 bushels. Further details regarding the management of such gigantic runs, the loading and unloading, the casting-off of a piece out of the fleet, the navigation impeded by many known and unknown obstacles, we must omit even to mention, but readers of the article will find that their time has not been wasted.—*Marine Engineering*, Oct. 1901, pp. 418-422. (Ill.)

Tank Steamers.—*Tank Steamer "Deutschland."* By O. C. Thomas. The consumption of American Petroleum and the business of transporting it are gigantic. Nearly all civilised countries take their share of this important illuminant and fuel, but Germany is one of the best customers of the United States, and the trade is excellently organised by the *Deutsch-Amerikanische Petroleum Gesellschaft*, having terminal headquarters in Hamburg and New York. Every month twenty or more so-called "tank-steamers" leave the United States for German ports carrying from 1,200,000 to 1,700,000 gallons each. Allowing for necessary repairs, each of these steamers makes an average of ten voyages a year, and on this basis the company therefore supplies the German empire with an average of 850,000 tons of oil annually. Bearing in mind the colossal dimensions of the trade, many persons will be glad to obtain an idea how the transport across the ocean is managed, and what is the construction and equipment of the vessels effecting this transport. The article published under the above heading, therefore, will be welcome, for it is devoted to one of the largest oil steamers afloat, *i.e.* the *Deutschland*, belonging to the fleet of the Society above mentioned, which in the month of May last year completed her sixty-eighth trip. Her length is 350 ft. over all, her beam 43 ft. 8 ins., her depth to spar-deck 21 ft., and to main deck 23 ft. 9 ins., while her designed capacity comprises 4,850 tons cargo, 700 tons coal, and 200 tons water.—*Marine Engineering*, Nov. 1901, pp. 422-24.

3. Pleasure Boats.

4. Engines and Equipment.

Anchors.—*Eynon's Patent Anchors.* The anchor to which the description given under the above heading

refers has been patented and recently placed upon the market by the Eynon's Patent Anchor Company, of Newcastle-on-Tyne. Its peculiarity consists in having an ingenious addition to its head of what may be called, says the writer, auxiliary trips, which guarantees an instantaneous grip the moment the anchor touches ground, since this causes the main arms automatically to take the correct angle of penetration, and dragging is absolutely avoided. At the same time, all difficulties arising from stiffness of the trips owing to rust or accumulated dirt are removed. The trips are of such length, number, and disposition as to take hold of the ground and to turn the arms so that the flukes enter it. One of the involved consequences of the instantaneous grip is that less cable has to be paid out, which is an item worthy of consideration where stockless anchors are concerned. Among other advantages of this, we are informed, there is the avoidance of canting over, due to the extra width that has been given to the head and to the crown pin. In support of these claims, we are informed that the Lloyd's and Bureau Veritas Registries have approved this new type of anchor, of which the original model received a first-class model for merit of design at the Royal Polytechnic Society's Exhibition held at Falmouth.—*Marine Engineer*, Dec. 1st, 1901, pp. 348, 349. (Ill.)

5. Miscellaneous.

Salving.—*Salving of the Steamer Willamette.* Under this heading the journal mentioned below publishes an interesting salving feat, which required not only ingenuity, but a good deal of pluck and perseverance. On March 16th last year, the steamship *Willamette*, of the Pacific Coast Steamship Company, while running from Comox, B.C., with 900 tons of coal cargo to Ladysmith, B.C., to finish loading, ran on submerged rocks off Denman Island, in Union Bay, B.C. Her position proved to be hopelessly perilous, as she had come to rest on the rocks at a point amidship under the main boilers and the hull structure being weakest at this point a partial cargo of coal at both ends aggravating the situation, the vessel soon broke in two, the outside plating parting abreast the fire-room on both sides. As the hull had broken in two parts, salving was deemed impracticable, and the wreck was sold by the underwriters on April 16th to the highest bidder. In this way the wreck became the property of Mr. Robert Moran, President of the Moran Brothers Company, Seattle Works, who ,having visited the scene of the misadventure, decided upon making an effort of salving the vessel, which seemed to him quite feasible. In the latter part of April, therefore, he started with a wrecking party and a suitable outfit to British Columbia. On arriving near the wreck, however, he was met by a number of Canadian Customs officers, who confiscated his salving outfit, and forbade all operations pending a decision of the Canadian Government regarding the legality of Mr. Moran's enterprise. Moreover, the men forming the wrecking crew, organised in Seattle, were placed under arrest, under the restrictions of the Canadian labour laws. Mr. Moran had believed that existing international treaty law entitled him to proceed, and had in mind the clause saying "United States vessels and wrecking appliances may salve any property wrecked, and may render aid and assistance to any vessel wrecked, disabled or in distress in *the waters of Canada contiguous to the United States.*" It had been, however, suggested to the Canadian officials by interested persons that the words which we have emphasized by italics clearly deprived Mr. Moran of the right of salving the *Willamette*, since the place where she was wrecked was not in waters "contiguous to the United States," for Union Bay was not directly bounded by United States territory. Ultimately a favourable decision was rendered by the Canadian Government, and Mr. Moran was authorized to go to work with his own crew. Meanwhile, however, most valuable time had been lost, and the damage done to the vessel by tides and weather had been constantly increasing. Upon their release the men started work at once and in good earnest. The plan which they followed was to attach the two halves of the vessel by a number of fore-and-aft bolts passed through sockets riveted in the hull, the bolts being intended to close the gap between the two halves. This done, and a large proportion of the cargo having been removed, the after-hold was pumped out preparatory to floating the vessel to a sandy beach near by where the repairs were to be completed. Unfortunately, at this critical period, a new obstacle arose, threatening failure to Mr. Moran's efforts: for the boilermakers among his crew having heard that their brother workmen in Seattle had gone out on a great strike, affecting the whole of the United States, declared that they could not continue work under existing circumstances, and, disregarding Mr. Moran's urgent need, immediately left him. Nothing daunted, however, the latter kept on working with his remaining men, carefully supervising every step, and the vessel was floated and beached as intended, and permanent repairs were begun. The latter, unfortunately, though carried down as low as practicable, could not be extended to the keel, which left a serious element of weakness, as the keel and keelsons, as well as the bottom plating, had been torn apart. As no more could be done without great trouble and delay, Mr. Moran decided to take the risk of floating the vessel in the condition in which it then was. In this, however, he failed, for during the operation of pumping out the afterhold, the vessel resting on the forefoot, the strength of the hull amidships proved to be insufficient to withstand the stress created, and the plates and bars so carefully and strongly riveted to the structure on both sides of the break, parted, and left the vessel again broken in two, as before the repairing was begun. That the effect was deeply depressing upon every member of the wrecking party may well be imagined, but Mr. Moran did not lose faith in his ultimate success. The first method having failed he tried a new plan. Instead of joining the two halves by means of steel plates and bars, he had a timber splice fitted on the outside of the shell. This splice consisted of a number of heavy and long timbers, bolted outboard to the ship's framing, through the shell, one timber over the other, from the waterline to the upper deck, each successive layer or strake being edge-bolted to the preceding strake, and thoroughly through-bolted through the ship's structure. It was not attempted to secure water-tightness on account of the break in the shell below the splice, which, of course, gave free access of water to the main fireroom. Many days were spent in hard and incessant labour ere the splice on both sides of the vessel was completed, and ere once more the operation of pumping out the hold, preparatory to floating the vessel, was begun, and all this time anxious uncertainty prevailed in the minds of those plucky men whether the wooden splice would give the strength that the steel splice had failed to secure. Mr. Moran's perseverance was rewarded however. The *Willamette* was floated to an even keel, pulled off the beach, and anchored in the bay. Though, as above mentioned, the water had free access to the fireroom, the adjoining bulkheads were properly braced, and found to be almost entirely watertight, so that both ends of the vessel could be kept quite dry without pumping. Under these circumstances the hiring of a tugboat would, one would think, have brought the adventure to a proper conclusion; but Mr. Moran's ambition was to bring the *Willamette* to Seattle under her own steam, propelling her own machinery. The latter was found to be in good condition owing to the good sense of the engineering crew of the *Willamette*, who at the time of the wreck had opened the oil tanks so as to allow the oil to flow into the engine-room to spread over all the exposed parts, so that the action of the tide caused them to be recoated with oil. It was, of course, not possible to use the main boilers for supplying steam, but Mr. Moran had installed a large fire-box boiler, brought from Seattle, on the upper deck of the vessel, which, during the earlier operations, had supplied steam to the pumps, the air compressor, and other apparatus in use. This boiler, together with the ship's donkey-boiler, happily being placed above the water-line in the fire-room, were united and connected with the main engines, and the arrangement worked so satisfactorily that on August 11th, 1901, the *Willamette* arrived at Seattle without mishap, having covered the distance from the scene of the wreck to that town, *i.e.* about 250 miles, at an average speed of about six knots per hour. That the salving of the vessel and her renovation, rendering her as good as new, was a profitable enterprise will be easily seen when it is stated that she is 315 ft. 6 ins. in length, 39 ft. 2 ins. in breadth, and 21 ft. 8 ins. in depth, was built in 1881 by John Roach & Son, at Chester, Pa., and refitted with modern machinery in 1898 by the Union Iron Works, of San Francisco, Cal.—*Marine Engineering*, Oct. 1901, pp. 405-8.

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Refuse Destructors.—*Refuse Destructor at Nelson.* Comments on a paper read at the annual Congress of the Royal Institute of Public Health last year by Mr. Priestley, in which the author describes a number of tests referring to refuse destruction recently made at Nelson with a furnace of the Meldrum regenerator type. The two chief features of interest in Mr. Priestley's paper, says the author, are the detailed description of the means adopted for determining the temperature in the combustion chamber, and the results of a test extending over a month from October 19th to March 16th last year. The temperature was ascertained by one of Callendar's recording pyrometers, an instrument based on the variation in the electrical resistance of a coil of platinum wire with variations of temperature. The temperature automatically recorded during the tests showed a maximum of 2,692 degs. F., and a minimum of 666 degs. F. There is, as the author points out, necessarily some difficulty in calculating a pyrometer such as used by Mr. Priestley, but the latter has apparently been very scrupulous in finding the true reading, and checked the results by independent tests. In the tests, lasting over a month, Mr. Priestley found the average evaporation of water per pound from refuse from and at 272 degs. F. to be 1·85 lb., which is a result almost identical with that obtained during a short one-hour test, and expresses the opinion that "the contention that evaporation results obtained on a short test are not trustworthy is thus effectually disposed of." The author of these comments begs to differ from this view for various reasons, but is at one with Mr. Priestley in laying stress upon the fact that in judging the efficiency of a destructor the complete destruction of the refuse is the main point, and has to be satisfactorily determined ere there can be any question of raising steam for industrial purposes.—*Electrical Review*, Nov. 1st, 1901, pp. 699, 700.

2. Engines and Motors.

Gas Engines.—*A 125-h.p. Nash Gas Engine.* This heading is followed by an article describing the latest improvement in the well-known Nash gas engines, aided by a cross-section of the engine, which is of the four-stroke cycle type, and a photographic view of the valve-gear and working parts. The engine referred to is vertical, enclosed, and self-oiling. The various parts of the mechanism are concisely but clearly described by the writer. A more condensed description would be useless, and it is therefore not attempted here. The reader interested in this subject will not regret having consulted the original. It may be mentioned, however, in conclusion, that this engine is provided with a self-starting device, operated by compressed air, consisting essentially, to quote the writer, of an air-compressor, an air reservoir, and a valve mechanism to operate one of the cylinders of the engine by compressed air. A single movement of the starting lever throws into action supplementary cams, so that the right-hand cylinder operates as a single-acting compound air engine, while the other two are placed ready to start up with gas. As soon as speed is attained, however, by means of the first cylinder and ignitions occur in the other two cylinders, the starting lever is moved back to its normal position, the air-starting mechanism is disconnected, and the machine operates as a gas engine.—*Engineering Record*, Nov. 2nd, 1901, pp. 732-3. (Ill.)

3. Machine Work, and Foundry.

Core-Wire.—*The Climax Core-Wire Straightener.* This appellation refers to machines that every foundryman using cores of any great dimensions will welcome. As the author of the description says: "Nearly every shop is blessed with a large accumulation of bent and twisted rods, from which the core-makers only select such as are easily straightened out. The result is that requisitions are continually made for new rods, while the old stock keeps growing larger." The Climax Core-Wire Straightener is a mechanical device by which crooked wire or rods fed into it at one side come out straight and ready for use in cores at the other side. The designer of the machine is Mr. George de Laval of East Cambridge, Mass., U.S.A., who, according to the journal quoted below, will place it upon the market within the near future.—*Foundry*, Nov. 1901, pp. 97, 98. (Ill.)

Cupolas.—*A New Cupola.* The cupola described under this heading has recently been brought out by Mr. John Barrett of Crosshills, near Keighley, and was seen in operation by the writer in the works of the Bremner Machine Company, Ltd., at Otley. The real difference between the cupola and those heretofore in use lies, according to the description, in the arrangement and shape of the tuyères. These latter, nine in number, are arranged in three tiers of three tuyères each. They are oblong in shape, and those at the top are not quite as deep as those below, and their arrangement is such that no two of them are in exactly the same line, so that there is a blast practically round the whole circumference of the cupola. This is said to produce a wonderfully even action in the cupola itself. Where the tuyères enter into the air-blast jacket, sliding doors are fitted into them which are controlled by hand through the ordinary observation holes, the covers of which are made removable. By means of these sliding doors the supply of blast may be regulated as required, and, says the writer, when nearing the end the top and middle row of tuyères may be entirely shut off one after another, and the blow completed with the bottom row alone, which obviates the necessity of blowing cold blasts against the melting iron. The widening out of the tuyères' mouths, and their arrangement abovementioned, is said to ensure an entirely even combustion throughout the melting zone, which, according to the makers, means a large saving of fuel, combined with very rapid melting, and results in the production of an exceedingly hot and fluid metal, that, on cooling, shows a remarkably uniform texture. The Bremner Machine Company is certainly well qualified to judge how the new cupola compares with the older type which it supplanted, and the writer informs us that they speak very highly of Mr. Barrett's modifications, and consider the results in every way satisfactory.—*Engineer*, Nov. 15, 1901, p. 514. (Ill.)

4. Machine Tools.

Riveting Tools.—*Pneumatic Tools.* By Mr. J. C. Taite. This is a paper read by the author at the International Engineering Congress, recently convened at Glasgow, in which the author confines his remarks almost entirely to pneumatic riveting, with special reference to such tools as were represented in the Exhibition buildings, such as the "Boyer" long-stroke hammer for shell-riveting, by which rivets up to 1¼ in. can be successfully knocked down, and of which he gives the essential details of construction and most noteworthy features. He also describes a riveting-hammer with tail-piece largely used in shipyards for bearer knees: tools for deck-riveting, and pneumatic tools for bridge-work, for which such tools are eminently suited, since they supply a desideratum of long standing, namely, an efficient plant for riveting *in situ* that can be easily moved from place to place. He quotes the following convincing remarks from a report by Mr. A. B. Manning, of the Missouri, Kansas, and Texas Railway, submitted to the Committee of the Association of Railway Superintendents of Bridges and Buildings at the annual convention in St. Louis in 1900: "Men with pneumatic riveter will average 500 rivets per day for 8·12 dols. (33*s.* 3*d.*), or 1·62 dols. (6*s.* 7*d.*) per hundred. Men with hand-power average 250 rivets per day for 9·20 dols. (37*s.* 8*d.*), or 3·68 dols. (15*s.*) per hundred." As regards the cost of riveting in England, the placing of ¾-in. rivets with pneumatic hammer is 7*s.* 6*d.* per hundred as against 10*s.* 6*d.* by hand. Another pneumatic tool described in Mr. Taite's paper is a motor with tube-cutter for locomotive work. It is similar to the ordinary drill, but having in addition an air-cylinder and piston which forces out a taper mandril, thus pressing the cutting edge of the tool against the tube. By the use of this tool 2¾-in. diameter steel tubes can be cut through in five seconds. Othr pneumatic tools for locomotive work mentioned in the paper are: a reversible drill with the ordinary tube expander now largely used for tube expanding: further pneumatic drills for drilling out stay-bolts and re-tapping the holes. These appliances give, it seems, great satisfaction, a saving of £7 per boiler having been effected in the cost of re-staying the fire-boxes at one of the principal yards, while railway-wagon floors riveted pneumatically have cost 15*s.* less per wagon. The saving in time has been equally conspicuous. Thus, a report from the shops of one of the French railways states that 16-in. manhole doors are cut in the locomotive boiler in 15 mins. through a plate ⅞ in. thick,

while 1¾-in. tubes are rolled in 27 secs. each. In general boiler-work pneumatic tools are being used with similar advantages. The speedily extending use of pneumatic tools has led to the adoption of much larger compressors than formerly, and many works which when opened were equipped with a Westinghouse air-pump giving 40 cub. ft. of air per minute, or an oscillating compressor giving 60 cub. ft., use at present compressors of a capacity of 300 to 350 cub. ft. In this country, as Mr. Taite points out, in conclusion, the fullest advantages in increased output and economy have not been reaped from the use of pneumatic tools, owing to the obstacles placed in the way by the Trade Unions, but the enormous savings effected by the use of pneumatic riveting in other countries must ultimately have their effect also in British workshops.—*Engineering*. Nov. 5th, pp. 614, 615. (Ill.)

Special Machinery.—*Bicycle Spoke-Making Machinery*. Under this heading is described a very ingenious set of machinery for making the spokes of bicycles, constructed in accordance with the patent of Mr. John Batey, of Harborne, near Birmingham. The machines constituting this set are of three kinds, "unique in construction and automatic in their working," and appear to be "a new departure both as regards their rate of production, and also as regards the special features of the product." The functions that these machines perform are those of stretching, straightening, cutting screwing, heading, and bending. "Two of the machines," says the writer, who has personally examined them, "are capable of performing the operations required for the production of 3,600 spokes per hour. The third machine, that for screwing, can turn out 700 spokes per hour." Six of these latter machines are required to keep pace with one of each of the other two machines. To enter into any detailed description of the process of manufacture is, of course, impossible in this place, owing to the exigences of space, but our readers will find in the publication quoted below a concise but lucid description of the various consecutive operations of each of the machines, accompanied by diagrams.—*Engineer*, Nov. 15th, 1901, p. 512. (Ill.)

5. Refrigeration and Cold Storage.

Air-Cooling.—*The Douglas Air-Cooling Tower*. There have been many attempts to devise a method of cooling air in connection with refrigeration, but they have been all more or less failures, because the majority of the experimenters, says the author of the contribution published under the above heading, have approached the problem from the purely mechanical point of view, thinking that the solution would be found in passing air over cooled surfaces, such as stacks of pipes through which cold brine is circulated, or over discs revolving in brine, but as air is very elastic and apt to elude intimate contact with solids or liquids the results remained unsatisfactory. The difficulty has always been to obtain the large surfaces most suitable within the comparatively small area allotted for the purpose. The device described is the work of an inventor intimate with the manufacture of vitriol, and who consequently had experience with the best method of securing the absorption of small percentages of acid vapours out of large volumes of gases. This, as is well known, is arranged by means of the so-called "Gay Lussac Tower," which is packed with pieces of coke, and in which the gases to be treated on passing up meet with a descending current of absorbing vitriol. The same principle is employed in the so-called coke "scrubbers" met with in gas-works, and coke towers have been used also for washing off traces of ammonia, and the condensation of tar out of enormous bulks of blast-furnace gases. For all these and similar objects coke is eminently fitted, not being affected by chemicals and able to withstand the corrosive action of strong vitriol and acid gases for many years, while, breaking in irregular pieces, it packs with many interstices, through which air passes easily and with a minimum of pressure. Moreover, its spongy nature and rough surface render it well adapted for the purpose of bringing gases and liquids in close contact with each other. The suggestion, therefore, that coke might play an important part also in cooling air by bringing it in contact with cold brine was natural enough, and experiments have fully borne out the value of coke for that purpose. The apparatus designed by Mr. T. Douglas, who has since ceded all his rights to Messrs. William Douglas & Sons, Ltd., Baltic Wharf, Putney, S.W., is based on the properties of coke above mentioned, and has, it appears, given excellent results. The article published under the heading above quoted, and describing its construction as well as the results of convincing experiments made with it, will be found below.—*Ice and Cold Storage*, Nov. 1901, pp. 289-90. (Ill.)

Refrigerating Machines.—*The Brewers' Exhibition*. This contribution deals with refrigerating machinery shown last year at the Agricultural Hall, London, during the twenty-third Brewers' Exhibition. Among them special notice is given to the latest type of the so-called "Simplex," a machine working on the ammonia absorption principle, and exhibited by its agents in the brewing trade, Messrs. G. Adlam & Sons, Bristol. All the fittings are of steel, the ammonia in the new type is contained in a hermetically sealed circuit, while the consumption of water is considerably reduced. The notice of this machine is followed by a short reference to two small size carbonic anhydride machines, a No. 3 and a No. 1: the former was shown at work, making 6 cwt. of beautifully transparent ice each day between the hours of 10 and 5. The concluding portion of the article is devoted to short notices of the refrigerators of Messrs. Hall, Crabtree & Heap, to patent filters exhibited by Messrs. Montague, Sharpe & Co., and to cylinders of compressed CO_2 gas shown by the Carbonic Acid Co.—*Cold Storage*, Nov. 15th, 1901, p. 216. (Ill.)

MINING AND METALLURGY.

1. Coal and Coke.

Coal Conveying.—*The Mechanical Handling of Coal, Ore and Pig Iron*. The writer, after a short introduction, in which he alludes to the fact that the era of hard manual labour is over, and refutes the fallacy that the increase of machine work is disadvantageous to the working-classes, proceeds to describe various types of conveyors, and among them a swinging conveyor of very simple construction, invented by Mr. Eugen Kreiss, and extensively used on the Continent (the agency in this country being in the hands of Mr. G. F. Zimmer, of 82, Mark Lane, London); the coal conveying machinery put up for railway service by the Link Belt Company, U.S.A.; the Simpson bucket conveyor, which also acts as an elevator; the Robins type of belt conveyor, introduced into this country by Messrs. Fraser & Chalmers, of Erith, and a conveyor installed three years ago by the Sterling Iron and Zinc Company, at North Mine Hill, Franklin, New Jersey, U.S.A. The article ends with a short reference to improved bunkers in which the coal is stored.—*Iron and Coal Trades Review*, Oct. 11th, pp. 825-9. (Ill.)

Inclined Coal Seams.—*The Working of Inclined Coal Seams in Westphalia*. A short paragraph, accompanied by sectional views, states that Mr. James Stirling, Government geologist of Victoria, recently visited one of the pits of the "Essener Bergwerks Verein," "König Wilhelm," in Bergeborbeck, in order to study the working of the Westphalian black coal seam, and also the washing and screening. The interesting feature in this seam is the very acute angle of its inclination. He found that it was worked by the board and pillar system. A brake shaft, so called from the method of winding used in it, is struck up the seam from the main level to the air level, and, on either side, levels are struck along the seam as far as possible, the distance depending on the prevailing local conditions. As soon as the limit is reached, another brake shaft is struck up, and the seam worked back towards the first shaft. The winding is described as a counter-weight balanced cage system, governed by a brake on the pulley.—*Iron and Coal Trades Review*, Oct. 4th, 1901, p. 864.

2. Copper.

Copper Ores.—*Cyaniding Cupriferous Ores*. By L. Janin, jun. Description of the treatment of the pyritic ores of the Lydenburg (Transvaal) District, which are composed of quartz, oxides of iron (when the ore is oxidised), some dolomite from the enclosing rock, and small quantities of manganese, bismuth, copper, and silver, which composition offers some interesting problems.—*Engineering and Mining Journal*, Aug. 17th, 1901, p. 197.

REVIEWS.

Theoretical Elements of Electrical Engineering.—By Charles Proteus Steinmetz. New York: *Electrical World and Engineer.* 327 pp., with diagrams.

This book has been divided by its author into two parts, the first dealing with the general theory of direct and alternating currents, while the second treats of special forms of electrical apparatus. The author, we are glad to say, has made no attempt to write a book for those who are unwilling, or unable, to cope with the mathematics necessary for proper study of this subject. Such books may serve a useful purpose, but they can never give a thorough understanding of the theory of alternating currents, for the simple reason that that theory is largely based on mathematical analysis. The present volume, therefore, assumes this requisite mathematical knowledge in the reader, but, having made this assumption, it provides him with a large amount of information. Beginning with the definition of "unit magnet pole," the author gives or derives the other magnetic units, and then defines the electric units by the magnetic effect they produce, or by their relation to a magnetic field. The fundamental principles of electro-magnetism are then very concisely stated, and the inter-relation of the various units clearly expounded. There is nothing in the book which may be lightly passed over, for from time to time the reader meets with expressions which seem to throw new light on matters with which he may have deemed himself familiar. This fact is of itself sufficient to make the book worth reading, for where so much is written it is not often we meet with originality and freshness in the writer. The author, however, has made the book still more attractive to the engineer by the numerous examples given and worked out. These examples are as practical as they could well be, and are evidently drawn from the author's extended experience in the design and operation of electrical apparatus. To each short section there is at least one example added, but the number is usually greater.

The second part of the book is less theoretical and more descriptive. It contains four sections devoted respectively to synchronous machines, commutating machines, synchronous converters, and induction machines. The characteristic features of the different machines, and their action under normal and abnormal conditions are shortly but clearly discussed. Where all is so good it is unnecessary to make special mention, but we may say that the discussion of induction machines, which occupies the last sixty pages of the volume, is especially deserving of attention. The polyphase and single-phase induction motor, the induction generator, induction booster, and phase-converter are there all briefly considered, and the section ends with a few pages on concatenation of induction motors. In our opinion, this book will be found useful by all students of modern electrical machinery.

The Induction Motor. A short Treatise on its Theory and Design, with numerous Experimental Data and Diagrams.—By B. A. Behrend. New York: *Electrical World and Engineer.* 105 pp. $1.50.

This book is disappointing. The author has undoubtedly had great experience with the electrical machine which he has set himself to describe in these pages, but his treatment of theory is not quite satisfactory. He does not possess the faculty of imparting his knowledge to his readers in a clear manner. Mr. Behrend is an enthusiastic advocate of the graphical method of treatment as opposed to the mathematical, but his enthusiasm has carried him too far. There can be no doubt that in many problems the use of graphics is most valuable, but graphics can never replace mathematics, and it is a great mistake to try to make them do so. But the author of the present volume is so enamoured of this method of treatment that, when he has finished his discussion of the theory of the polyphase motor, he calls upon us to look back admiringly upon the easy road by which he has led us. He then continues as follows:—"Slowly but surely graphical methods have supplanted and will supplant in the future, highly analytical methods, as in the graphical method the development of the idea can be followed stage by stage, thus furnishing a means of constantly checking the process of reasoning and keeping the attention of the mind concentrated upon the development of the thought, while a long analytical argument, after starting out from certain premises, leaves us in large measure in the dark until the result is reached. In my opinion the didactic value of graphic methods is vested in the difference traced out in the above comparison." This argumentative statement has to be modified a little in the following paragraph, where we are told that in many cases the analytical method is more simple than the graphical, and the simpler method is always to be preferred. It is somewhat curious that in a book published by the same publishers contemporaneously with this volume, and written by an author whose experience of electrical machinery is certainly not less than that of Mr. Behrend, we should find the answer to the latter's argument. In the preface to his "Elements of Electrical Engineering" (reviewed above), Mr. Steinmetz says, "Especially of late years, electrical literature has been haunted by so many theories (for instance, of the induction machine) which are incorrect, or too complicated for use, or valueless in practical application. In the class last mentioned are most of the graphical methods, which, while they may give an approximate insight into the inter-relation of phenomena, fail entirely in engineering practice owing to the great difference in the magnitudes of the vectors in the same diagram, and to the synthetic method of graphical representation, which generally requires one to start with the quantity which the diagram is intended to determine."

But even when we make allowance for the author's enthusiasm for graphical methods, we do not find the book attractive. There is a want of clearness and of originality in his theoretical dis-

cussion, which is the more to be regretted in that the purely practical parts contain some useful information. We regret not to be able to recommend a book the writing of which has been to the author "mainly a labour of love"; but when so much electrical literature is being showered upon the public, we have to pay most attention to the result of the author's labour and not to the motives which inspired it.

Surveying and Levelling Instruments Theoretically and Practically Described. —By William Ford Stanley. Third edition. London: E. & F. Spon, 1901.

Mr. Stanley's book on Surveying Instruments is well known as a standard guide to such appliances, and the new edition is even more valuable than its predecessors. It is very seldom that busy men engaged in manufacture can spare time for literary work, apart from the production of catalogues or prospectuses setting forth the advantages of their specialities. Moreover, one is naturally inclined to suppose that any business man who becomes the author of a book dealing with apparatus of the kind made by him may be rather biassed in his literary treatment of the subject. We have a double pleasure in welcoming the present edition of Mr. Stanley's work, for it is not only an admirable and thoroughly practical treatise, but is at the same time free from any attempt at self-advertisement. The author's own instruments are, of course, mentioned freely throughout the volume, but this would have happened even if the treatise had been written by another hand, and we are pleased to observe that Mr. Stanley is always ready to acknowledge the good work done by other firms, and to speak favourably of inventions in which he is not personally interested. After a brief historical sketch, the author gives a general classification and some notes upon the manufacture and care of instruments which ought to be of considerable assistance to young surveyors. He then proceeds to describe various essential parts of surveying instruments in general, devoting special attention to the telescope and the magnetic compass. Levels of all kinds, levelling staves, the practice of levelling, and similar matters are next considered in detail, and after a chapter dealing with the division of the circle and the methods employed in taking angles, the author passes on to describe old and new forms of theodolites for various purposes. In this section of the work we find details of several recent types of instruments which have distinctly advantageous features. Mining survey instruments and subtense measuring instruments receive adequate attention in the two following chapters, a noteworthy feature, as such appliances have hitherto been somewhat scantily noticed in technical literature. Inclinometers, instruments of reflection, graphic surveying instruments, and direct measuring instruments are afterwards described very fully, and the volume concludes with notes upon miscellaneous instruments and appliances for the use of surveyors and engineers. There is a good deal of new matter in the edition, some of it being due to suggestions from professional men in response to an invitation contained in the preface to the first edition. Mr. Stanley's book is most complete in every way, and in our opinion is an absolute essential in the office of every surveyor and civil engineer.

Fowler's Mechanical Engineers' Pocket Book for 1901. Edited by William Fowler. Manchester: The Scientific Publishing Co. 1*s.* net; leather gilt, 2*s.* 6*d.*

This is the new edition, brought up to date, of an excellent *vade-mecum* which from its first appearance found favour in the engineering world, and has continued to enjoy this favour owing to the care taken by its editor and publishers to render it a reliable guide and a ready source of information to all for whom it is intended. Only those whose work carries them into localities where libraries are unknown institutions and where it is impossible to carry with them even the most essential books of reference, except those that can be put into the pocket or find a corner in the saddle-bag, can fully appreciate the value of this standard publication which, notwithstanding its small size, contains an almost incredible amount of information expressed in the most concise form and rendered accessible by a thoroughly adequate index. Half-a-hundred pages of index in a little volume of not more than four hundred pages may, at a first glance, seem too much of a good thing, but we are convinced that few who know Fowler's Pocket Book will complain of the size of this guide to its contents, for an index in publications of this kind can hardly be too full, since it saves an enormous amount of time which would otherwise be wasted in finding the exact place by searching under various headings, under each of which it might be, but in most cases is not, found, or in looking up cross references in an index restricted by attaching a dozen figures to one and the same word instead of adopting a more complete subdivision with a corresponding number of entries in the index. The figures in the tables and formulas, so far as we have been able to test them, are very accurate and the descriptive portions are as free from verbiage as possible, while the clearly printed figures accompanying the text give, in most cases, more complete information than could be obtained from a verbal explanation occupying twice or three times their place. If we add to this that the type is clear, that the binding of the little volume is solid, that the corners are nicely rounded so as to prevent their breaking, it will be admitted that the price above given is merely nominal, and in no proportion whatever to the usefulness of this creditable publication. We may add, in conclusion, that the "Buyers' Directory" accompanying the text is a feature of great convenience to intending purchasers, and of considerable value to advertisers, since the latter, owing to the deservedly large circulation of the Pocket Book, are able to address their offers to a very numerous section of the public.